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DEVELOPMENT OF A REGIONA SIMULATING THE SOUTH AFRIC CIAL CONSIDERATION TO RISK

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Abstract

Wheat is the second most important field crop grown in South Afric the form of bread which is one of the main staple foods in South Af tem. However in recent years there has been a trend to a more free the consequences of alternative marketing policies for wheat warra ming model was developed with the objective of simulating the whea various crops, substitution in demand between wheat and maize a average yield data could be misrepresentative when used in risk an results show that the model successfully simulates production in th estimated shadow price of land being similar to actual rents and by tween actual and predicted land use and production respectively. It

Samevatting

In terme van bruto waarde is koring die tweede belangrikste akke verbruik in die vorm van brood wat een van die belangrikste stap vasteprysskema bemark. Die afgelope paar jaar was daar egter 'n n ondersoek na die gevolge van alternatiewe bemarkingsbeleidsrigting meringsmodel op streeksbasis ontwikkel om die koringbedryf te si verskeie gewasse, substitusie in die vraag tussen koring en mielies delde opbrengstes individuele risiko uitkanseleer is daar gebruik ge produksie in die belangrikste koringproduserende streke in Suid-Af grond wat soortgelyk is aan die werklike huur en deur die persenta tussen werklike en voorspelde grondgebruik en produksie. Daar w beleidsnavorsing.

1. Introduction

The economic importance of wheat production to South Africa can be summarised as follows : 1) Wheat contributes significantly to the total gross value of agricultural production; 2) wheat in the form of bread is one of the major staple foods in South Africa; 3) the domestic production of wheat results in the reduction of wheat imports which leads to savings on foreign exchange; 4) the wheat industry and its related secondary industries provide considerable employment.

Given the economic importance of wheat the future production and marketing of wheat need to be researched. At present wheat is marketed under a one-channel fixed-price system. To evaluate the consequences on domestic production of different marketing alternatives a linear programming (LP) model of wheat production at the regional level was developed. The model includes negative-sloping demand functions for crops, substitution in demand between wheat and maize, and variance-covariance matrices to account for income risk.

In the first part of the paper the development of the LP model is discussed, with the objective of simulating production in the South African wheat industry. Special consideration is given to in supply was included in the model. The area under the supp function of a crop also comprises the opportunity cost producing that product (Nieuwoudt,1981).

In the OFS/Tvl region there are three main crops that compe with wheat for land, namely maize, sorghum and sunflowers. the Swartland the competing crops are oats and pastures (f sheep and dairy herds). In the Rûens oats, barley and pastur for sheep are the main competing enterprises.

2.3 Cost Data

For cash crops, use was made of the General Farm Manag ment Results, a publication by the Directorate of Agricultu Production Economics. These cost estimates relate to an enti production region. Owing to the lack of more detailed data, was assumed that costs were constant over each producti region. This assumption was partially relaxed in RHF where rainfall was considerably lower than the relevant produ tion region. In these areas observed production costs we reduced as fertilizer was applied at significantly lower rates.

For the sheep and dairy enterprises, use was made of Comb reports compiled by the Directorate of Agricultural Producti Economics.

2.4 Yields

Yields and stocking rates for the various RHFAs were obtain from Scheepers *et al* (1984) and the Landbo Ontwikkelingsprogram (1985). For the magisterial districts central Orange Free State yield data were taken from Agric tural census reports which is a publication by the Departme of Statistics (1972).

2.5 Rotation of Crops

Account was taken of physical restraints on the production crops in each production region. For example, sunflowers c only be grown once every three years (owing largely to disea and pest problems). Consequently the (annual) model allo only one-third of the land available for sunflowers in an RH to be planted to sunflowers. Likewise wheat can only be gro in five of eight consecutive years in the OFS/Tvl region. In t Cape, the success of wheat production depends largely on t amount of soil moisture present in the soil at planting. For th reason if wheat is grown in a monoculture it is grown usin wheat fallow rotation. These and other rotation consideratio were included in the model.

2.6 Supply of Inputs

The supply of inputs to production activities was assumed be either perfectly elastic or perfectly inelastic. The supply land, being a constraint, was considered perfectly inelastic. other inputs were supplied at a fixed price.

2.7 Risk

The approach developed by Hazell and Scandizzo (1974) w used to include risk in the model. In this study risk was counted for by the deviations of gross income per hectare fro the trend line. With the mean absolute deviation meth developed by Hazell and Scandizzo (1974) risk can be includ as a cost factor in the objective function. Hazell and Nort (1986:89) provide an example of an LP matrix which expla the inclusion of risk. In this model estimates of the standa deviation were used, a procedure followed by Frank (198 Ortmann (1985), Nieuwoudt *et al* (1976), and Simmons a Pomareda (1975). Each production region was given its o risk aversion coefficient (θ). This permits "fine tuning" to g the best simulation of farming production in the differe regions. There has been criticism for calling θ a risk aversi coefficient. As Hazell (1982) points out, when altering θ to fi

Table 2 Yield standard deviations, and pooled yields of wheat, barley an

Farm	Standard Deviation Wheat	Barley	Oats
1	0,192	0,353	0,264
2	0,368	0,486	0,724
3	0,467	0,361	0,389
4	0,226	0,642	1,380
5	0,457	0,596	0,508
6	0,360	0,456	0,493
Average annual Yields	0,245	0,346	0,455
Pooled Yields	0,401	0,546	0,816

Considerable differences exist among farms with respect to yield standard deviation. The range of standard deviation for wheat is from 0,192 for farm 1 to 0,467 for farm 3. The range for barley is from 0,353 for farm 1 to 0,642 for farm 4. For oats the range is from 0,264 for farm 1 to 1,38 for farm 4. From the data farm 1 seems to have a consistently low yield variability and farms 4 and 5 a high yield variability.

As mentioned earlier, yield variability based on average yields is expected to be lower than individual farm variability. This is highlighted here especially in the case of barley where the average variability is lower than for any of the individual farms. However, pooled yield variability tends to be representative of the "average" variability of individual farms.

Significant differences in relationships are observed among farms. Correlation coefficients for wheat and barley range from -0,34 for farm 3 to 0,88 for farm 4. Wheat and oats yield correlation coefficients ranging from -0,31 for farm 2 to 0,49 for farm 4. For barley and oats the range is from -0,23 for farm 2 to 0,82 for farm 6. It appears that the correlation coefficients for average yields are biased upwards when comparing them to individual correlation coefficients. For example, the average correlation coefficient for wheat/oats is 0,45 yet only one farm (farm 4) has a correlation coefficient slightly greater than this. It can be seen that the pooled yield data has a correlation coefficient roughly "average" of those experienced on the six farms for the three crops.

In light of these results it was decided to use a pooled data set. Gross incomes for each crop for individual farms were taken from the Mail-in Record System for the Rûens and Swartland production regions (Directorate of Agricultural Production Economics 1981 to 1986). Information from six farms for six years for each production region was used.

A dummy variable model was fitted for each crop's gross income with linear and quadratic slope coefficients for time trend varying across farms.

$$G_{iT} = b_{0i} + b_{1i}T + b_{2i}T^2 + e_{iT} \qquad (1)$$

Where:

G_{iT} = Gross income on the ith farm at time T.
b_{0i} = The intercept for the ith farm.
b_{1i} = The linear slope coefficient for the ith farm.
b_{2i} = The quadratic slope coefficient for the ith farm.
e_{iT} = Residual error for the ith farm at time T.

The method used to estimate equation 1 was ordinary least squares. Different intercepts for the individual farms were taken to represent different management practices, soil types

These estimates were transformed into demand functions. Th area beneath the demand function (P = a - bQ) is given by th integral of the function as follows :

$$W = Q(a - 0.5bQ) \quad (2$$

Where : P = product price.
a = constant.
b = slope of the function.
Q = aggregate quantity demanded
W = area beneath the demand function (total welfare)

This function is not linear so it cannot be entered directly in a linear program. However, it can be linearized by using th Duloy and Norton (1973) technique : the demand function divided into segments and the area beneath the demand func tion up to each consecutive segment is calculated. The welfa values for different quantities are then calculated. These we fare values were used in the objective row of the LP matrix enable total consumer surplus to be maximised. Each segme is then entered into the LP matrix as a separate activity, but constraint ensures that only one of these activities enters th solution at any one time.

Regional demand functions were estimated for those crop where only a percentage of the total crop is grown in th wheat-growing regions. This was done by utilising the metho proposed by Kutcher (1972) and used by Ortmann (1985) an Frank (1986).

The welfare values calculated hold if there is no substitution demand. However, there appears to be a significant cros elasticity between the demand for maize and wheat. Van Z (1985) estimated this cross-price elasticity to be 0,2. The qua tities and welfares of the consumption of maize and whe were calculated at different prices for the two crops. Total we fare was calculated by adding the individual welfares derive from maize and wheat consumption at different prices. The t tal welfare vector was entered into the objective function of th matrix.

Export demands were assumed to be perfectly elastic due South Africa's small share of world markets. Shifts in deman due to changes in income were ignored.

2.10 The model

The objective function of the model can now be expressed follows :

$$\text{Max } Z = [X'M(A\text{-}0.5BMX)] - \sum_{i=1}^{N} \{[C'X]_i + [\theta_i (X'\Omega X)^{0.5}{}_i]\} \quad ($$

The first term of equation 3 measures total welfare, which the integral of the linear product demand function P = A BMX, where M is a nxn diagonal matrix of average yields p hectare and X is a nxl vector of aggregate hectares generat endogenously within the model. Production costs are deduct in the second term [C'X] where C is a vector of producti costs per hectare. Costs associated with risk are deducted in t last term, where Ω is a variance-covariance matrix of gross i comes per hectare, θ_i is an aggregate "risk aversion" coefficie for all farms in region i and N the number of major regio (three in this study).

3. Simulation

Before the model can be used to evaluate alternative whe policies, results must be compared with present cropping pa terns. This also provides a check on cost data. To do this, cu rent policies relevant to the different crops were imposed

Table 5: **Production under different risk aversion (1000t)**

Region	Actual Production	Simulated Production at		
OFS/Tvl		$\theta=0{,}10$	$\theta=0{,}30$	$\theta=0{,}50$
Wheat	813,9	558,3	806,0	835,1
Maize	1955,8	2572,6	2021,9	1672,0
Sorghum	26,8	0,0	73,3	94,6
Sunflower	72,7	58,4	97,1	167,0
Oats	20,3	22,5	22,5	22,5
Corr, Coefficient		0,979	0,999	0,996
PAD		31,7 %	5,1%	16,2%
Swartland		$\theta=0{,}25$	$\theta=0{,}35$	$\theta=0{,}50$
Wheat	354,4	359,8	359,8	271,3
Oats	10,8	104,3	81,2	116,1
PAD		27,1%	20,7%	51,6%
Rûens		$\theta=0{,}50$	$\theta=0{,}60$	$\theta=1{,}00$
Wheat	273,4	348,4	278,2	259,4
Barley	107,8	91,6	109,5	110,9
Oats	15,8	15,1	15,1	0,0
PAD		23,2%	1,8%	8,3%
Overall Corr, Coef,		0,979	0,999	0,994
Overall PAD		30,3%	6,3%	18,9%

PAD - Percentage absolute deviation.

For the Rûens region a θ value of 0,60 results in the best correlation coefficient and PAD of 0,976 and 9,4 per cent respectively. An increase in θ results in a decrease in the area of wheat and oats and an increase in the area of barley and pastures. The overall correlation coefficient and PAD are good, being 0,997 and 12,2 per cent respectively.

The results of the second test are shown in Table 5. The production of different crops in the OFS/Tvl region is simulated closely at the optimum θ value (0,30) giving a correlation coefficient and PAD of 0,999 and 5,1 per cent respectively. Simulation of production in the Swartland region is poor which is mainly due to the poor simulation of oats production. One reason for this is that the actual production figure recorded does not account for oats produced but fed to livestock. If this data were available there would be an improvement in the PAD for the Swartland region. The production of wheat, barley and oats in the Rûens region is simulated closely at the optimum θ value (0,60). The overall PAD value of 6.3 per cent indicates that close simulation was obtained.

Interesting to note is that the production of wheat in the Swartland and Rûens regions decreases with an increase in θ, but increases in the OFS/Tvl region, highlighting the differences in wheat production in the winter rainfall region compared to the summer rainfall region.

Estimates of actual rent data were acquired from regional extension officers and economists in the different production regions (Coetzee 1987; Laubsher 1987; Purchase 1987). Results of the land-rent test are presented in Table 6.

The fact that the shadow prices of land at the optimum θ values are similar to the actual rents, shows that the costs used in the model are representative of the real production costs.

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