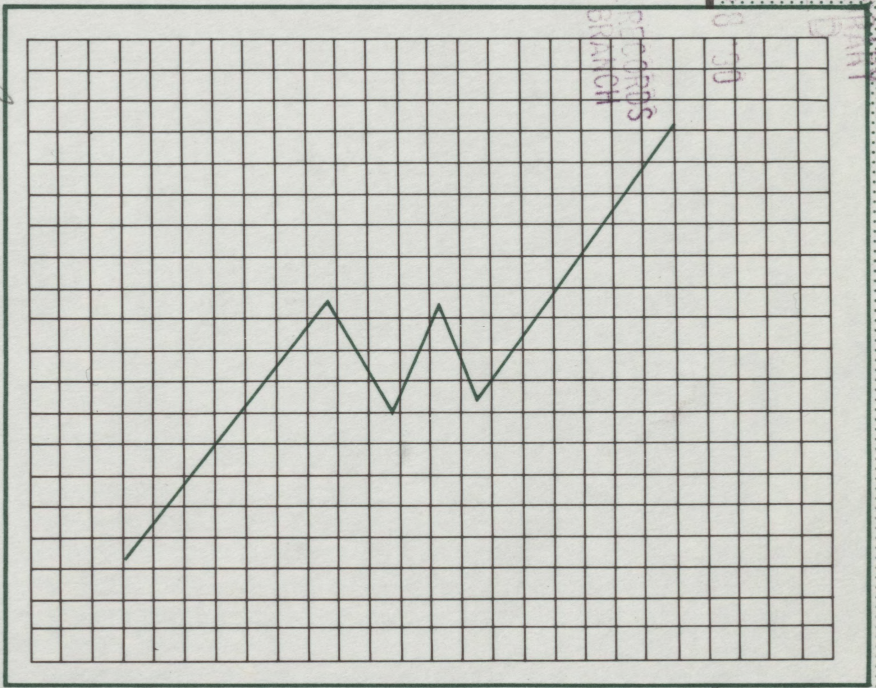

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STRUCTURAL ASPECTS OF BEEF PRODUCTION ON PASTURES IN THE SUMMER RAINFALL GRAIN PRODUCING AREAS OF SOUTH AFRICA

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ABSTRACT

A dynamic linear programming matrix is assembled in order to model the South African summer grain industry. Supply, demand and production risk, including interactions with production substitutes, are considered. The model is tested by imposing all of the policies which were in operation at that time to see if it adequately simulates the prevailing situation. The model is used to evaluate the possible structural effects of subsidising farmers to change over land under cash crop production to pastures for beef, taking into account the inter-relationships in grain markets in Southern Africa. These effects are evaluated under different marketing policies with regard to changes in land use, prices, labour requirements and producer and consumer welfare.

The main conclusion reached from this analysis is that by reforming or helping some industry or group of producers, its problems are merely transferred to other industries or producers owing to the inter-relationships in agriculture and the economy. It emphasises the need for an overall policy plan.

INTRODUCTION

There is at present a conscious effort by NAMPO, the Maize Board, the Department of Agriculture and Water Supply, the Department of Agricultural Economics and Marketing and the SAAU to promote the substitution for maize production on marginal crop land of pastures (Mielies/Maize, 1987; 1988). The basic idea is to decrease the supply of maize and to increase both the income of farmers and their stability (Ferreira, 1987). A Government subsidy is also available for farmers who substitute pastures for maize production on marginal crop-land, given certain conditions (Mostert, 1988).

The proposed change-over will have definite economic consequences for producers, consumers and related industries. The effect on producers was, to some extent, examined by Mostert (1988) and Van Zyl & Nel (1988) researched and analysed the impact of changes in the maize industry on prices and production in the rest of the economy. This analysis examines the effects of the subsidy scheme for planting marginal maize land to pastures on land use, prices, labour requirements and producer and consumer welfare. A macro-view is taken. This is done by assembling a dynamic linear programming model of the South African summer rainfall grain producing area and simulating different policy measures.

First, this article describes how a dynamic linear programming matrix was assembled in order to model the South African summer grain industry. Supply, demand and production risk, including interactions with possible substitute and complementary products, were considered. The model is tested by imposing all of the policies which were in operation at that time on the model to see if it adequately simulates the prevailing situation.

Second, the article evaluates the possible effects of subsidising farmers to change over marginal maize land to pastures, taking into account the inter-relationships in grain markets in South Africa. These effects are evaluated under different possible policy alternatives for the marketing of maize and substitute products with regard to changes in land use, prices, labour requirements and producer and consumer welfare.

MODEL DEVELOPMENT

Following Frank (1986) and Hazell & Norton (1986), the sectoral linear programming model was developed over three stages: First, the basic model with costs and fixed prices was assembled. Next, risk was included using MOTAD and, finally, variable product prices were modelled by using stepped demand functions. These were combined in a linear programming matrix in order to model the summer rainfall grain producing area. A detailed mathematical formulation of a sectoral linear programming model can be found in Hazell & Norton (1986) and Ortmann (1988) and is therefore not repeated here.

The basic model

In a perfect model, each farm should be modelled independently. However, this is not viable. Homogeneous regions, i.e. areas with similar yield and costs per hectare, were therefore identified. The summer rainfall grain producing area of South Africa was divided into magisterial districts, 92 homogeneous resource regions in all.

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There are six main crops which compete for cropping land in each of the homogeneous regions: maize, wheat, sorghum, sunflowers, ground-nuts and pastures for beef. The supply of each product is upward sloping because costs differ between regions and because of competition for land within regions.

Detailed yield data were obtained from the Agricultural Census Reports and the Directorate of Agricultural Economics Trends of the Department of Agricultural Economics and Marketing. Yields were based on data from 1976 to 1985, 10 years in all. Cost data were obtained from surveys done by the Department of Agriculture and Water Supply and from three annual publications by the Directorate of Agricultural Economics' General Farm Management Results, Combud and Mail-in-Record Results. All costs have been inflated or deflated by the price index for farming requisites (Abstract, 1988) into 1985 rands. This year was chosen because it is representative of the situation before changes in the marketing system for maize took place. Returns to scale were assumed to be constant.

The supply of inputs to the production activities is assumed to be either perfectly elastic or perfectly inelastic. The supply of land is assumed to be perfectly inelastic and is therefore a constraint. All other inputs, including labour, are supplied at a constant price. Although Nieuwoudt *et al.* (1976) and Ortmann (1985) included upward sloping supply functions for labour to refine their models, labour is assumed to be perfectly elastic in this model. An unemployment rate in excess of 25 per cent in the rural areas of South Africa (Van Zyl & Vink, 1988) supports this assumption. The total amount of arable land available in any one of the resource areas was taken to be the sum of the areas planted to maize, wheat, sorghum, sunflowers and ground-nuts. Any additional arable land that might be available is assumed to be negligible or unavailable for these crops.

Inclusion of risk data

Farmers base their cropping decisions not only on the profitability of each crop, but also on the crop's riskiness. There are three main sources of risk, namely yield uncertainty, price uncertainty and cost uncertainty. Gross income variations were used as a measure of risk because of the lack of time series cost data. Deviations from the mean gross income per hectare were calculated for each resource area and crop for the period 1976 to 1985. MOTAD was used to incorporate risk into the linear programming matrix, similar to methods used by Hazell & Scandizzo (1974), Hazell & Norton (1986) and Ortmann (1988). Risk can be considered an additional cost, namely the additional return that farmers want as compensation for taking risk (Barry & Frazer, 1976). The inclusion of risk therefore means that the supply curve shifts to the left.

Stepped demand functions

Using the techniques described by Hazell & Norton (1986), the demand for each product was modelled making possible the endogenous generation of equilibrium prices. The data needed were flexibility estimates for each crop for each of its uses (for example, animal demand, human demand and export demand), the current mean quantity consumed and the price. The inverse of the elasticity of demand was used as a flexibility estimate. Elasticities of demand used in this study were derived from the work of Nieuwoudt (1973; 1976; 1983), Laubscher (1982), Frank (1986) and Van Zyl (1986; 1988).

A regional demand function was calculated for wheat because only 60 per cent of the wheat crop is grown in the summer rainfull grain producing area. This was done by using the method proposed by Kutcher (1972) and used by Ortmann (1985) and Frank (1986).

The consumer surplus associated with any quantity is given by the area beneath the demand function. Prices, producer income and welfare values for different quantities of the mean quantity consumed were calculated. These welfare values were used in the objective row of the linear programming matrix to enable total surplus to be maximised.

The welfare values calculated hold if there is no substitution in demand. However, there appears to be a significant cross-elasticity between the human demand for maize and wheat, and between the animal demand for maize and sorghum. The quantities and welfare of the human consumption of maize and wheat and the quantities and welfare of the animal consumption of maize and sorghum were calculated at different prices for maize and wheat and maize and sorghum, respectively. Total welfare was calculated by adding the individual welfare derived from maize and wheat consumption and maize and sorghum consumption at different prices. The total welfare vector was entered into the objective function of the matrix.

Shifts in the demand because of changes in income were ignored.

Final model

A fairly sophisticated linear programming model was developed. Substitution in supply was modelled by including six different crops in each of the 92 resource regions. Allowance was made for producer risk aversion by using MOTAD. It encourages crop diversification in regions, making the solutions more realistic. Twelve demand functions for the six products were incorporated into the model by using elasticity estimates and current prices and quantities. Ten of these were downward sloping and needed to be linearised by dividing them into steps. Substitutions between maize and wheat and maize and sorghum were likewise modelled. This stepwise modeling technique causes solutions to be discontinuous or discrete. This may cause the model to be insensitive, especially if the steps are large. However, in this model there are 92 resource regions, 100 steps in the maize-wheat and maize-sorghum welfare surfaces, respectively, and 20 steps in th other demand functions. This should cause the model to be adequately sensitive.

MODEL VALIDATION AND CALIBRATION

The degree to which the model simulates the current situation is a measure of its reliability. If the simulation is good, one can have some confidence in the model's ability to compare various policies. The testing of the data was done by imposing all of the policies which were in operation in 1985. Maize and wheat were marketed under a fixed price scheme, sorghum was marketed under a floor price scheme and sunflowers and ground-nuts were marketed under a pool scheme.

Two tests were used for the simulation, namely:

- regional production areas, and
- product prices.

Each test compares a particular set of parameters generated by the model with actual base year (1985) values. Results of the two tests are presented in Tables 1 and 2.

Table 1 presents the quantities of various crops produced in each region under different risk aversion coefficients. As the risk aversion coefficient (θ) increases, so more risky crops decrease and less risky crops increase. The best simulation, indicated by the correlation coefficients, was obtained with a θ-value of 0,3. Although some of the deviations seem to be large in relative terms (Table 1), they are generally small in absolute terms.

The second test, in Table 2, compares actual prices with dual prices generated by the model. Maize and wheat prices do not vary with different values of θ because of the fixed-price marketing schemes. Because of the linear relationship between prices and quantities a θ-value of θ,3 also gives the best "fit".

The risk aversion coefficient (θ) of 0,3 compares favourably with other studies using the

TABLE 1. Deviations of equilibrium solutions generated by the model from the actual cropping pattern for various risk aversion coefficients (Θ)

Area	Product	Actual area planted 1 000 ha	Risk aversion coefficient		
			Θ =0,1	Θ = 0,3	Θ = 0,5
	Maize	1 167	– 0,4	– 0,4	– 0,4
	Wheat	10	– 6,5	+ 4,5	+ 4,5
W.Tvl	Sorghum	31	+ 5,0	+ 5,0	+ 5,0
	Sunflowers	61	– 0,6	– 0,6	– 0,6
	Ground-nuts	48	+ 17,2	+ 4,6	+ 4,6
	Maize	807	+ 17,3	+ 4,5	– 9,4
	Wheat	44	– 100,0	– 60,5	– 60,5
E.Tvl	Sorghum	83	– 100,0	+ 2,8	+ 138,2
	Sunflowers	75	– 3,3	– 3,3	– 3,3
	Ground-nuts	10	– 100,0	– 100,0	– 63,6
	Maize	910	+ 8,1	– 1,3	– 4,2
	Wheat	206	+ 2,6	– 2,6	+ 2,6
N.W. O.F.S	Sorghum	45	– 100,0	+ 0,1	+ 0,1
	Sunflowers	74	– 48,2	+ 7,7	+ 7,7
	Ground-nuts	46	– 100,0	+ 1,7	+ 1,7
	Maize	549	+ 17,0	+ 0,3	– 5,1
	Wheat	367	– 27,9	– 10,1	+ 15,2
E. O.F.S.	Sorghum	57	– 48,2	+ 7,7	+ 7,7
	Sunflowers	44	+ 4,7	+ 4,7	+ 4,7
	Ground-nuts	1	– 100,0	– 100,0	– 100,0
	Maize	160	+ 2,7	– 0,2	– 2,3
	Wheat	162	– 0,9	– 0,9	– 0,9
N.Tvl	Sorghum	27	+ 78,7	– 12,9	– 64,1
	Sunflowers	38	+ 1,7	+ 1,7	+ 1,7
	Ground-nuts	44	+ 10,4	+ 10,4	+ 10,4
	Maize	224	+ 0,3	– 0,6	– 24,6
	Wheat	297	– 7,2	– 15,7	– 32,5
S.W. O.F.S	Sorghum	6	+ 296,4	+ 296,4	+ 296,4
	Sunflowers	47	– 69,8	– 53,8	– 44,5
	Ground-nuts	10	– 100,0	– 100,0	– 100,0
	Maize	211	– 20,3	– 0,4	+ 17,5
	Wheat	0	0,0	0,0	0,0
Natal	Sorghum	3	– 100,0	– 100,0	– 100,0
	Sunflowers	3	– 100,0	– 100,0	– 100,0
	Ground-nuts	3	+ 178,6	+ 178,6	+ 178,6
	Maize	194	+ 17,7	+ 5,1	– 1,2
	Wheat	30	– 18,0	– 18,0	– 18,0
N.Cape	Sorghum	9	– 100,0	– 100,0	– 100,0
	Sunflowers	12	+ 33,2	+ 33,2	+ 33,2
	Ground-nuts	74	– 6,0	+ 1,0	+ 8,9
Correlation coefficient (r)		**1 000**	**0,964**	**0,982**	**0,977**

TABLE 2. Deviations of dual prices generated by the model from actual prices for various risk aversion coefficients (ϴ)

Product	Percentage deviation for various values of θ		
	ϴ=0,1	ϴ=0,3 %	ϴ=0,5
Maize	0,0	0,0	0,0
Wheat	0,0	0,0	0,0
Sorghum	0,0	0,0	0,0
Sunflowers	+2,2	+0,5	-1,7
Ground-nuts	0,0	0,0	0,0

same technique. It is slightly more than the θ-value of 0,25 derived by Ortmann (1984), slightly less than the θ-value of 0,50 obtained by Frank (1986) and Simmons & Pomerada (1975) and less than the value of 2,0 obtained by Nieuwoudt *et al.* (1976). However, not much emphasis need be placed on this value. The correlation coefficients indicate that the situation has been adequately simulated and that the model should be fairly reliable in predicting the effects of different policies.

POLICY TESTING RESULTS

The policy testing stage is divided into two sections. First, meat production on pastures is introduced as an additional production activity in the summer rainfall grain-producing areas under the marketing policies in operation in 1985. Secondly, a free and competitive market system for all products is introduced.

Five important assumptions must be borne in mind while interpreting these results. First, the model is static and hence industries do not react to changes other than those specified in the model. Second, adjustment is frictionless, costless, and timeless. Third, industries are protected from foreign imports and fourth, changes in output, prices and structure of industries not specified in the model in reaction to modelled changes are not taken into account. Last, but very important, the model maximises total welfare, which may deviate from actual behaviour in the face of change.

Criteria used to compare the policy simulations are land use, product prices, labour requirements and welfare transfers.

Land use

The changes in land use with the introduction of subsidised pastures under the current marketing policies and a free market policy for all products, respectively, are shown in Table 3.

According to Table 3 it seems that only minor structural changes will take place if pastures are introduced under the current policies. The total area cultivated will decrease by only 0,5 per cent, while pastures will constitute 3,6 per cent of the total original area cultivated. The substitution for land under maize cultivation of pastures will take place in the Western Transvaal, Eastern O.F.S., South-Western O.F.S. and Northern Cape, in particular. According to the model, no pastures will be planted in the Eastern Transvaal and Natal under the current policies.

A free market for all the products will result in major structural changes in crop production in the summer rainfall grain producing areas of South Africa. The total area cultivated will decrease by more than 25 per cent, with the largest reductions in the Eastern O.F.S., the Northern Transvaal, the South-Western O.F.S., Natal and the Northern Cape. Only the non-marginal production areas of the Western Transvaal, Eastern Transvaal and North-Western O.F.S. will undergo relatively smaller structural changes. Farmers will not be able to substitute pastures for all the land that is withdrawn from maize production. This will also result in changes in the production patterns of wheat, sorghum, sunflowers and ground-nuts, as indicated by the model. According to the model, 40 per cent of the total area under pastures will be in the Eastern Transvaal. This shows that it does not necessarily mean that only marginal land will be planted to pastures.

Prices

Table 4 shows the changes in relative prices under the various policies from the base values generated by the model using the current policies without pastures. If pastures are introduced as an alternative production activity, prices for the various products will stay the same, except for ground-nuts and meat, which will decline by 2,8 and 6,8 per cent, respectively. However, under a free market policy, prices for all the products will decline by at least eight per cent, except for the price of sorghum, which will stay the same.

Labour requirements

Changes in total labour requirements under the various policies from base values generated by the model with the current policies without pastures are shown in Table 5. Labour requirements will stay fairly constant if pastures are introduced as an additional production activity under the current policies, but will decline by 27,4 per cent under a free market policy for all products. This decline is slightly more than the 26,3 per cent decline in the total area under cultivation (Table 3). The substitution for maize cultivation of pastures, which are less labour intensive, is mainly responsible for this difference.

Welfare aspects

Welfare transfers are very important when considering the effects of policy changes. Transfers take place between producers and consumers and between producers within regions. Welfare transfers do not only occur as a result of the introduction of pastures as an alternative production activity, but are also a function of the marketing policies in operation for the various products. Table 6 summarises the welfare transfers that will take place owing to the specified changes in policy. These welfare transfers refer to both transfers that take place between producers and consumers and those between

TABLE 3. Changes in land use with the introduction of subsidised pastures under current marketing policies and a free market policy, respectively

Item: Area	Item: Product	Base values generated by the model base on current policies ha	Percentage change in area: Current policies with pastures %	Percentage change in area: Free market with pastures %
W.Tvl	Maize	1 162 706	− 12,7	− 12,7
	Wheat	10 914	0,0	0,0
	Sorghum	32 077	0,0	−100,0
	Sunflowers	60 514	0,0	0,0
	Ground-nuts	49 999	0,0	0,0
	Pastures	0	[1])	[1])
	Total area	1 316 210	− 2,5	− 4,9
E.Tvl	Maize	843 796	+ 2,1	− 4,9
	Wheat	17 555	−100,0	−100,0
	Sorghum	85 291	0,0	0,0
	Sunflowers	72 438	0,0	−100,0
	Ground-nuts	0	0,0	0,0
	Pastures	0	0,0	[7])
	Total area	1 019 080	0,0	0,0
N.W. O.F.S.	Maize	898 467	− 5,2	− 5,2
	Wheat	210 899	+ 2,9	+ 2,9
	Sorghum	45 263	0,0	−100,0
	Sunflowers	79 188	0,0	0,0
	Ground-nuts	46 313	0,0	0,0
	Pastures	0	[2])	[2])
	Total area	1 280 130	+ 1,7	− 1,8
E. O.F.S.	Maize	550 911	− 8,3	−100,0
	Wheat	338 111	+ 1,7	+ 37,0
	Sorghum	38 142	0,0	−100,0
	Sunflowers	45 963	0,0	0,0
	Ground-nuts	0	0,0	0,0
	Pastures	0	[3])	[3])
	Total area	973 127	− 1,0	− 44,6
N.Tvl	Maize	159 328	− 0,0	− 6,3
	Wheat	160 236	+ 5,3	−100,0
	Sorghum	23 230	0,0	−100,0
	Sunflowers	38 190	0,0	0,0
	Ground-nuts	48 375	− 62,9	−100,0
	Pastures	0	[4])	[8])
	Total area	429 359	− 10,0	−100,0
S.W. O.F.S.	Maize	222 765	− 10,0	−100,0
	Wheat	250 609	0,0	−100,0
	Sorghum	25 529	0,0	−100,0
	Sunflowers	21 672	0,0	−100,0
	Ground-nuts	0	0,0	0,0
	Pastures	0	[5])	[5])
	Total area	520 575	− 3,3	− 99,1
Natal	Maize	210 034	− 1,8	− 39,7
	Wheat	0	0,0	0,0
	Sorghum	0	0,0	0,0
	Sunflowers	0	0,0	0,0
	Ground-nuts	9 696	+216,6	−100,0
	Pastures	0	0,0	0,0
	Total area	219 730	+ 7,8	− 42,4
N. Cape	Maize	203 668	− 14,5	−100,0
	Wheat	24 321	0,0	−100,0
	Sorghum	0	0,0	0,0
	Sunflowers	15 362	0,0	0,0
	Ground-nuts	75 239	0,0	− 10,3
	Pastures	0	[6])	[6])
	Total area	318 590	− 2,6	− 72,1
Total area		**6 076 801**	**− 1,5**	**− 26,3**

[1]) Increased from 0 ha to 114 102 ha
[2]) Increased from 0 ha to 18 677 ha
[3]) Increased from 0 ha to 30 149 ha
[4]) Increased from 0 ha to 20 873 ha
[5]) Increased from 0 ha to 4 914 ha
[6]) Increased from 0 ha to 21 368 ha
[7]) Increased from 0 ha to 190 068 ha
[8]) Increased from 0 ha to 42 889 ha

TABLE 4. Changes in prices under various policies from base values generated by the model with the current policies

Product	Percentage change in prices	
	Current policies with pastures	Free market policy with pastures
	%	
Maize	0,0	-10,6
Wheat	0,0	-15,5
Ground-nuts	-2,8	- 9,3
Sorghum	0,0	0,0
Sunflowers	0,0	- 8,6
Meat (beef)	-6,8	-14,3

TABLE 5. Changes in total labour requirements under various policies from base values generated by the model with the current policies

Policy	Value
Current policies (without pastures)	55,8 million labour days
Current policies (with pastures)	55,5 million labour days
Free market policies (with pastures)	40,5 million labour days

TABLE 6. Changes in producer and consumer welfare with the introduction of subsidised pastures under the current marketing policies and a free market policy, respectively

Item	Percentage change in welfare	
	Current policies with pastures	Free market policy with pastures
	%	
Change in producer welfare		
Western Transvaal	- 3,7	-36,8
Eastern Transvaal	+ 0,1	-22,2
North-Western O.F.S.	- 2,6	-37,9
Eastern O.F.S.	+ 0,1	-29,7
Northern Transvaal	+14,6	-30,3
South-Western O.F.S.	- 10,1	-84,0
Natal	+23,7	-49,2
Northern Cape	- 16,2	-75,7
Total producer surplus	**-2,1**	**-31,2**
Change in consumer surplus		
Maize	+ 1,8	+31,6
Wheat	0,0	+38,0
Sorghum	- 1,4	+24,4
Sunflowers	0,0	+ 6,3
Ground-nuts	+16,7	+14,9
Meat (beef)	+ 5,7	+21,6
Total consumer surplus	**+ 1,3**	**+30,7**
Change in total surplus	**+ 0,9**	**+21,4**

producers within the specified production areas. The producer surplus is calculated by deducting the total cost of the product from the total welfare derived by consuming it and adjusting the total by the relevant subsidies (Mishan, 1971). In this regard it is important to note that a free market policy for all crops is the only policy where social-costs are zero. The free market policy thus illustrates how other policies distort production and consumption patterns.

According to Table 6, the total surplus will increase slightly with the introduction of pastures as an alternative production activity under the current policies in operation. The producer surplus will decrease by 2,1 per cent, while the consumer surplus will increase by 1,3 per cent. A transfer of welfare will therefore take place from producers to consumers mainly because of lower beef and ground-nut prices. Changes within the different groups of producers on a geographical basis show that the welfare of producers in the Northern Transvaal and Natal will increase by more than 10 per cent, while the producer welfare in the South-Western O.F.S. and the Northern Cape will decline by more than 10 per cent.

These changes are, however, relatively small against welfare transfers that will take place under a free market policy with pastures. This highlights the distortions that result from current policies. A free market policy for all products will result in a substantial increase in the total surplus (21,4 per cent) and a substantial transfer of welfare from producers to consumers. Lower prices are the major reasons for this. Producers in the South-Western O.F.S. and the Northern Cape will experience the greatest decline in welfare. Table 7 shows the changes in the relative contributions of total producer and consumer surpluses to total surplus under the different policies.

TABLE 7. Changes in the relative contributions of total producer and consumer surpluses to total surplus under different marketing arrangements

Item	Policy		
	Current policies without pastures	Current policies with pastures	Free market with pastures
Producer surplus	33,9	32,4	20,9
Consumer surplus	66,1	67,6	79,1
Total surplus	**100,0**	**100,0**	**100,0**

Table 7 shows that there is a transfer of relative welfare from producers to consumers under alternative policies. The transfer is moderate given the current policies with pastures, but substantial under a free market for all products with pastures.

CONCLUSION

Policy changes such as the introduction of subsidised pastures or different marketing policies will result in changes in land use, product prices, consumption patterns and labour requirements and welfare transfers between producer groups and between producers and consumers in the summer rainfall grain producing areas of South Africa.

In general, it may be said that the introduction of subsidised pastures as an additional production activity in the summer rainfall grain producing areas will have only relatively minor effects under current policies (1985). It will be marginally beneficial to the total welfare and consumer welfare will increase. Producer welfare will, however, decrease. Structural changes with regard to land use and profitability within the various producer areas will be greater, especially in the marginal areas such as the Eastern O.F.S., South-Western O.F.S. and Northern Cape. A substitution for land under maize cultivation of pastures will, however, be relatively small and localised. The total area cultivated will decrease by 0,5 per cent and pastures will constitute only 3,5 per cent of the total original area cultivated.

However, a change to a free market policy for all products, with no imports allowed, will result in major changes in land use, prices, consumption and labour requirements and in significant welfare transfers between producer groups and from producers to consumers. An important finding is that farmers will not be able to substitute pastures for all the land that is withdrawn from maize production, in particular.

The results should, however, be interpreted against the assumptions and shortcomings of the model. Changes in other industries and areas are not taken into account. The rest of the beef industry and wheat industry (and others) will certainly interact with and react to changes specified in the model. The model is also only as good as the data. Cost data are hard to come by and the model is sensitive to changes in yields and production costs. However, simulation of the current situation provides a test for the data. There is, however, no test for the slopes of the demand functions. Economies of scale and production practices are also assumed to be constant. The further the shift away from the current situation, the more severe the errors are likely to be. This may lead to problems in the case of a free market policy for all products which results in relatively major changes. The objective function can also lead to serious errors. However, the results generated by this model prove to be adequate for the intended purpose, namely to illustrate the inter-dependence in grain markets.

The main conclusion of this analysis is therefore that by reforming or helping some industry or group of producers, its problems are merely transferred to other industries or products owing to the inter-relationships that exist in the economy and agriculture. Different policy options have definite implications for welfare transfers, land use, consumption patterns, prices and labour requirements. This highlights the need for an overall policy plan which considers all related industries and products simultaneously. *Ad hoc* policy measures, such as the substitution for maize cultivation of subsidised pastures, have to be evaluated in this context.

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