

AN ANALYSIS OF THE IMPACT OF DIFFERENT SCENARIOS ON THE MARKET FOR STOCKFEED PROTEINS IN SOUTH AFRICA

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The objective of this paper is to present the results from a study which was done to analyse the operation of the demand for and supply of the most important stockfeed proteins (maize, wheat, sorghum, oilseeds and fishmeal). A sectoral mathematical model was developed to analyse the economic impact of changes in the market for stockfeed proteins on the South African animal feed market. The model was used to simulate the effects of arbitrarily chosen scenarios on key parameters. Results indicate that models, such as these, are indispensable planning tools in situations of uncertainty. Relatively small changes in important things like production costs, yields and international prices often have profound influences on local production patterns and profitability. It clearly illustrates that in an environment of free domestic trade and increased international trade liberalisation, factors outside of agricultural policy have much larger impacts than agricultural policy.

1. INTRODUCTION

South Africa is experiencing an increasing shortage of locally produced stockfeed proteins. Table 1 provides actual production and consumption figures for oilcakes, the major source of animal feed protein in South Africa, for the period 1994-97. It is expected that the shortage, which will have to be met from imports, will become more profound, since Nieuwoudt (1997:42) has predicted that feedlot beef production will increase by 57.4% from 1995/96 to 2020.

There are many factors contributing to the observed phenomenon, including factors concerning the demand and supply of stockfeed proteins, marketing factors, factors concerning self-sufficiency and international trade and other factors like transport tariffs and policy. Moreover, these factors are changing, causing uncertainty in planning. Information regarding these changes in prices, quantities, welfare and production patterns is not readily available, but is required for planning and the formulation of suitable policies.

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Table 1: Local production, requirements and imports of oilcakes

Oilcakes	Years		
	1994/95	1995/96	1996/97
Requirements:			
Groundnuts oilcake	11 128	8 025	11 770
Sunflower oilcake	147 840	215 040	267 100
Soya oilcake	40 000	36 160	56 000
Cotton oilcake	30 000	19 587	66 692
Canola	3 432	7 150	4 785
Total requirement	<i>526 100</i>	<i>653 243</i>	<i>754 853</i>
Less: Local production	232 400	285 962	406 347
Import requirement	<i>293 700</i>	<i>367 281</i>	<i>348 506</i>

Sources: Oilseeds Board (1996), Cotton Board (1996), AFMA (1996).

The objective of this paper is to present the results from a study (Esterhuizen, 1998) which was done to analyse the operation of the demand for and supply of the most important stockfeed proteins (maize, wheat, sorghum, oilseeds and fishmeal). The model developed can be used to analyse the economic impact of changes in the market for stockfeed proteins on the South African animal feed market. For the purpose of the study a sectoral mathematical model has been constructed.

The paper is organised as follows: the next section provides a description of the model constructed for the analysis followed by a description of the data requirements and the testing of the model for its accuracy and predicting abilities. The model is subsequently used to simulate a number of different policy scenarios and its effect on the market for stockfeed proteins. The paper ends with a conclusion.

2. THE MODEL

2.1 Description

The analysis is based on a regional mathematical model. The construction of the model was done in three distinct phases (see Frank, 1986; Hazell & Norton, 1986 and Ortmann, 1988). First the basic model with costs and fixed prices only was assembled. Next, risk was included by using the mean absolute deviation method (MOTAD). Finally, variable product and input prices were modelled by using stepped demand functions.

In this model, South Africa was divided into the nine provinces, which are considered to be relatively homogeneous regions. The advantage of working with the nine provinces is that the data requirements can be more easily met. It is also more realistic to give answers for the nine provinces, which can help them in the policy-making process. Three import or export 'regions' or points were also included, namely Durban, Cape Town and Port Elizabeth.

It is important to identify those crops that compete for land and other resources so that the alternatives that face the farmer are also specified in the computer model. In this way, substitution in supply is included in the model. The supply of each product is upward sloping because costs differ between regions and because the crops compete with one another for land within regions.

Risk can be considered as a cost, namely the additional expected return that farmers want as compensation for taking risk (Barry & Fraser, 1976:288). Risk associated with various enterprises was taken as the deviations of gross income per hectare from the mean or from the trend line over a period of time as the enterprise price elasticities relate price and yield variabilities to income variability. The Motad methodology (Hazell, 1971) is used to introduce risk into the model. The additional data requirements are time series profit data, for the past six years, for each crop in each region. The risk aversion coefficient (in Motad) is parameterised and the value that gives the "best fit" is assumed to be an aggregate measure of the farmers' risk aversion (Simmons & Pomareda, 1975). Rather than placing too much weight on the significance of the actual numerical value of the risk aversion coefficient, it was used as a "fine tuning" device in order to get the model to simulate the real situation as closely as possible.

Demand for each product was approximated by including stepped demand functions in the model, using the methodology suggested by Duloy & Norton (1973). In order to use this technique elasticity estimates for each crop for each of its uses (e.g. animal demand, human demand and export demand), the current mean quantity consumed and the price are the data requirements. Price elasticities were taken from a document by Liebenberg & Groenewald (1997) which provides a summary of all studies already done on price elasticities. Use of linear demand curves confronting a region enables product prices to be generated within the model. One approach is to derive regional demand slopes from national demand slopes. The regional demand functions are thus "scaled-down" national demand functions (Kutcher, 1983).

In a competitive market system, consumer and producer surpluses are

maximised. Consequently, maximisation of the total area under the demand curve less the total area under the product supply curve results in a market equilibrium solution.

Transport opportunities/activities link the supply and demand sections of the model together: each of the nine resource regions or three import harbours can supply any of the twelve consumption points (nine regions and three export harbours). Supply and demand for each region is treated as if it is coming from a point or one specific locality, rather than from all over a region. This is done to make the treatment of transport costs between and within resource regions easier. Consumption and production points were subsequently developed to facilitate this. These production and consumption points differ for every region, so that interregional transport costs apply. The assumption thus is that transport costs from any point in a region to any point in another region are the same. This is in line with the assumption that production practices, yields, risks and prices are the same within regions. Thus, in order to simulate production of and trade in the selected crops between the different provinces of the RSA, the model consists of five basic but integral parts:

- *The supply side:* Provincial production of each of the selected crops; imports from the international markets at the three harbours; and imports from other provinces.
- *The demand side:* Local demand and demand in each province; and exports to international markets.
- *The linking activities:* Transport costs between provinces, and to and from harbours for each crop.
- *Risk:* The incorporation of production risk in provinces (MOTAD)
- *Demand, welfare and producer income:* An equation for each product under consideration

The model has been structured in such a way as to allow for the easy measurement of producer, consumer and total welfare of each product that forms part of the different objective functions, depending on the scenario followed.

2.2 Data

The data requirements were quite formidable as the data had not necessarily been collected or published in the required format. Several sources were used to collect the data. These include AFMA, the Department of Agriculture, Maize Board, Wheat Board, Oilseeds Board, Cotton Board, the SA fishmeal marketing company, Spoornet, and agricultural co-operatives. The distinguishing feature of agricultural sector models is that they are based largely on cross-section data rather than on time series. They are also validated against a single base year rather than against a time series. The production vectors are compiled from cross-sectional data on farm budgets, and the base-year data set on prices and quantities is another kind of cross section. Time series data is needed, however, for the risk sub-matrix, and in many cases this is one of the more difficult data requirements to fulfil. The 1995/96-production year was chosen as base year for setting up the model. All the price and quantity data refer to this year. For the construction of the model the data requirements are as follows:

- production, area and yield data for every commodity in each of the nine provinces. The commodities are white maize, yellow maize, wheat, sorghum, sunflower, groundnuts, soya beans, cotton, canola and fishmeal;
- production costs for every commodity in each of the nine provinces;
- c.i.f. prices and harbour handling costs for every commodity;
- net export prices of the commodities that are exported;
- base prices and quantities of each commodity's consumption in each of the twelve demand points in order to determine the step-wise demand schedules for each region;
- transport costs from every supply point to every consumption (demand) point;
- demand elasticities for each of the commodities;
- risk data consisting of prices and yields of every commodity for the six year period 1990/91- 1995/96.

2.3 Model validation

Validation begins with a series of comparisons of model results with the reported actual values of the variables. Although many validation tests are relevant, only the production and price tests were used here. Production is the variable most commonly used in validation tests, and for a number of agricultural models there are reported validation results for it (Hazell and Norton, 1986).

Typically, there is considerable variation between products in the closeness of the fit to the historical data. Greater deviations in minor products can be accepted if the predictions are good for the major products. A threshold value of the percentage absolute deviation (PAD) that clearly determines acceptance or rejection of the model does not exist. In this study, a deviation of 15% is deemed acceptable for the model as a general rule of thumb (suggested by Hazell & Norton, 1986). Production tests were also carried out in each province and not just for the country as a whole. Normally the fit is better at the aggregate level because within a sector model, at the level of a region, the tendency is towards over specialisation in the dominant crops, although the inclusion of risk-averse behaviour in the model specification greatly reduces that tendency.

The model was tested after some additional restrictions were imposed on the model. These include restrictions on the total area (hectares) that could be planted to a crop in each province. Restrictions were also imposed on the maximum and minimum area that could be planted to each product in the provinces. A minimum restriction of 1 650 000 tons was also placed on the amount of protein that must be produced in the country.

The values generated by the model corresponded fairly well with the actual values. A PAD of less than 15% across all the production regions was obtained which is particularly good for this type of model. When each product was evaluated separately the same good results were obtained. The price test also corresponds fairly well with actual values. The model can thus be accepted as being relatively accurate and can be used for simulating the effects of changes in the market for stockfeed proteins on the South African animal feed market, with some confidence.

3. APPLICATION OF THE MODEL AND DISCUSSION OF RESULTS

The model described and validated above can be used to analyse the impact of a range of policy and other scenarios on the market for stock feed by comparing results of simulated changes with that of the base scenario. Only a few of these different scenarios were selected, namely the effects of a national drought, increases in production and/or transportation costs, decrease in yellow maize yields or a cost increase in the production of yellow maize, increase in the yield and price of soybeans. The different scenarios are discussed next and the results summarised in Table 2. Much more information is available from the model, but space constraints prohibit the detailed presentation and discussion of these.

3.1 An expected drought in the whole country

To model this scenario, the yields for all the products produced in the coastal provinces e.g. Natal, Eastern Cape, Western Cape and Northern Cape were arbitrarily dropped by 20% from the 1995/96 actual yields. Yields for the products produced in the rest of the provinces were dropped by 25%.

Results indicate that the total production of every product will decrease, except for the production of sunflower, which will increase by 18.14%. The reason for this is that sunflower has more drought-resistant characteristics (relevant to other crops). Because of the decrease in total production, total imports will increase by 81.71%. Wheat imports will increase by 128.05% and cotton imports by 50.56%. Fishmeal imports will increase by 11.06% because of the shortage of locally produced proteins. Total exports will decrease by 95.06% with a 100% decrease in exports of maize.

The prices of sorghum, wheat, white maize, yellow maize and canola will rise, while the price of the other products will stay unchanged. The reason for this is that the local price of soybeans, sunflower and cotton is mainly determined by import parity price of these products. The price of protein will rise by 53.65% to R966.02 per ton. The effect of drought, in this scenario, on producer welfare is relatively large. Producer welfare will decrease by 54.40%. Consumer welfare will decrease by only 0.18%. Total welfare will decrease by 8.86%.

Table 2: The effect of the simulated scenarios on the gap between the demand for and supply of locally produced stockfeed proteins

Scenarios	Gap between demand and supply	Increase/decrease in gap(tons)	Percentage increase/decrease in gap (%)
Base Solution	171 208		
An expected drought	460 624	289 416(↑)	69.0 (↑)
5% increase in production costs	199 117	27 909 (↑)	6.3 (↑)
10% increase in transport costs	184 317	13 109 (↑)	.7 (↑)
10% decrease in the yield of yellow maize	207 032	35 824 (↑)	0.9 (↑)
10% increase in production costs of yellow maize	162 009	9 199 (↓)	5.4 (↓)
10% increase in the yield of soybeans	143 922	27 285 (↓)	15.9(↓)
10% increase in the price of soybeans	153 083	18 124 (↓)	10.6(↓)

3.2 General increase of 5% in production costs

This scenario was included because of the historical annual increases in production costs and also because of new policies, e.g. the possible introduction land taxes and water prices. In this scenario, the production cost for each commodity produced in every province was increased by a moderate 5%.

Results indicate that the increase in production costs resulted in a drop of total production of 3.41%. Less white maize will be produced and more wheat. Total imports will decrease by 15.42%, due to the decline of 26.40% in imports of wheat. However, total exports will decrease by 33.39%. The effects on commodity prices are minimal. There will be a slight decrease in the prices of sunflower, wheat and canola. The price of sorghum will increase by 0.46%. There will also be a slight decrease of 6.69% in the price of protein. This decrease is due to a reduction in wheat imports because of increased local production, and thus lower prices. Consumer welfare will remain unchanged. Producer welfare will, however, decrease by 7.24%. The effect of this decrease in producer welfare will also decrease the total welfare by 1.16%.

3.3 An increase of 10% in transport costs

Transport costs play an important role in the economy of South Africa and particularly in the market for stockfeed proteins. In this scenario, the transport costs of all products transported between provinces and to and from harbours were increased by 10%.

Results indicate that total production will decrease as a result of a 10% increase in transport costs. The production of soybeans (102.65%) and wheat (8.68%) will increase because it will be cheaper to produce these products domestically than to import them. The production of sorghum will increase (1.54%), mainly due to the fact that sorghum is mainly used by home-mixers and home-mixing reduces transport costs. The production of white maize will decrease because the profit in exporting white maize from provinces far from the harbours will decline. There will also be a small decrease in the production of sunflower (0.29%). Imports of soybeans (-44.59%) and wheat (-26.40%) will decrease because it will be more expensive to transport products from the harbours. Total imports will decrease by 22.52%. Total exports will also decrease by 46.11%. The demand for sorghum will increase because the on-farm use of sorghum reduces transport costs. The demand for sunflower seed will decrease slightly by 0.29%. The real impact this scenario has on the stockfeed market can be seen through the effect on welfare. Consumer welfare will increase by a small percentage, namely 0.01%. Producer welfare, however, will decrease by 2.02% or by R71 million. Total welfare will thus decrease by 0.32%.

3.4 Changes in yield and production costs of yellow maize

These two scenarios were modelled separately to determine the important effect changes in the market for yellow maize, as the main product used by the stockfeed industry, have on the market for stockfeed protein and welfare. In the first scenario, the yield of yellow maize was decreased by 10%. In the second scenario, the production cost of yellow maize was increased by 10%.

The main result of the drop in maize yields is the increased production of sunflower (1.54%) and sorghum (2.92%). Imports of soybeans (0.64%), wheat (3.52%) and fishmeal (4.62%) will increase to substitute for the lower production of yellow maize. Total imports will increase by 3.07%. Total exports will decrease by 16.41% because of the cut in the production of white maize. The demand for soybeans (0.45%), sorghum (2.92%), sunflower (1.54%) and fishmeal (3.51%) will increase to substitute for the decrease in protein availability due to the lower yellow maize production. The demand for

yellow maize will decrease by 3.47%. The price of sorghum, sunflower, wheat, white maize and canola will increase by only a marginal percentage. The price of yellow maize will, however, increase by 11.60%, because of the shortage in yellow maize. The shadow price of protein will increase by 45.43%. Consumer welfare resulting from yellow maize consumption will decrease by 2.30%. Total consumer welfare will decrease by 0.14%. Producer welfare will decrease by 5.72%. There will thus be a significant loss in producer welfare. Total welfare will decrease by 1.03%.

The increase in production costs of maize will lead to a decrease in the production of wheat (0.06%), white maize (2.18%) and yellow maize (1.51%). Production of soybeans (64.69%), sorghum (2.64%) and sunflower (0.28%) will increase because of the 10% increase in the production costs of yellow maize. Soybean and sorghum production will increase mainly in Mpumalanga, mainly because it will not be profitable to produce yellow maize and farmers will seek alternative products with higher profitability. An increase of 14.23% in the production of yellow maize in the North West Province again emphasises the comparative advantage over the other provinces this province has in the production of yellow maize. Imports of soybeans will decrease by 28.10% because of higher production. However, imports of fishmeal will increase by 2.36% to substitute for the loss in protein because of lower yellow maize production. Total imports will decrease by 3.90%. Total exports will decrease by 6.14%. The demand for sorghum (2.64%), sunflower (0.28%) and fishmeal (1.79%) will increase, while the demand for yellow maize (-1.51%) will decrease. Thus, sorghum, sunflower and fishmeal will be substituted for yellow maize in the mixing of stockfeed. The prices of all the products will stay unchanged, except for the price of yellow maize, which will increase by 6.68% because of the shortage in production. The shadow price of protein will increase by 27.98%. Consumer welfare (-0.04%), producer welfare (-3.58%) and total welfare (-0.61%) will decrease.

3.5 An increase of 10% in the yield of soybeans

This scenario was included to illustrate quantitatively what the impact of improved technology and/or varieties are on the key parameters. In this scenario the yield of soybeans was increased in all provinces by 10%, as though a new cultivar with improved yields had been developed.

Results indicate that the production of soybeans will increase by 167.10%. The specific percentage, however, is relative. What is more important is that the production of soybeans will increase substantially. Total white maize (-6.06%) and wheat (-1.16%) production will, however, decrease because of increased

soybean production. Imports of soybeans will decrease by 72.59%. Total imports will decrease by 9.50 %. Because of the lower production of white maize, exports of white maize will decrease by 17.45%. Total exports will then decrease by 17.12%. The price of soybeans will decrease by 5.47% because of the increased availability of cheaper locally produced soybeans and a decline in imports of more expensive soybeans. The price of white maize will decline, while the prices of sorghum, sunflower, wheat, yellow maize and canola will increase.

An important consequence of an increase in the yield of soybeans is that producer welfare will increase. Producer welfare will increase by 0.74% or by R26 million. Total welfare will increase by 0.12%. These results are important and can be used to argue the case for the importance of research into the market for stockfeed protein. Consumer welfare stays unchanged.

3.6 An increase of 10% in the price of soybeans

Since domestic agricultural markets are liberated and relatively free, local prices of agricultural products are determined by supply and demand. In this scenario, the world price, as well as the local price of soybeans, were increased by 10%. In terms of the model it means fixing these prices at a level that is 10 % higher.

Results indicate that, with a 10% increase in the price of soybeans, the production of soybeans will increase by 145.25%. Farmers will have to substitute wheat and white maize production for soybean production. The production of sorghum (2.64%), sunflower (0.26%) and yellow maize (1.31%) will also increase by small percentages. Imports of soybeans will decrease by 74.83%. Imports of wheat and fishmeal will increase by relatively small percentages. Total imports will decrease by 9.39%. Exports of white maize will decrease by 22.44% because of lower production. The demand for soybeans will decrease by 8.18%, due to the higher price. Soybeans will be substituted by sorghum (2.64%), sunflower (0.26%), yellow maize (1.31%) and fishmeal (1.79%) resulting in an increased demand for these products. The prices of all the products will increase, except for the prices of groundnuts, cotton and fishmeal (mainly because of the increased demand). The price of protein will increase by 27.25%.

Total consumer welfare will increase by 0.08%. Producer welfare, however, will decrease by 0.81%, mainly due to the decrease in the exports of white maize. Total welfare will decrease by 0.06%.

4. CONCLUSION

This paper describes a regional planning model, which can be used to determine the effects of changes in the South African stockfeed market on a variety of key parameters. These include, among others, production, consumption and exports, imports of commodities by province, prices of the commodities by province, and welfare estimates (producers, consumer welfare). The model provides a relatively good simulation of the actual situation, and can be used for simulating changes with some degree of confidence.

The model was used to simulate the effects of these arbitrarily chose scenarios, namely the effects of a national drought, increases in production and/or transportation costs, decrease in yellow maize yields or a cost increase in the production of yellow maize, increase in the yield and price of soybeans on these key parameters. Results indicate that models, such as these, are indispensable planning tools in situations of uncertainty. Relatively small changes in important things like production costs, yields and international prices often have profound influences on local production patterns and profitability. It clearly illustrates that in an environment of free domestic trade and increased international trade liberalisation, factors outside of agricultural policy have much larger impacts than agricultural policy.

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