The economic impact of ethanol production on the South African animal feed industry

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Abstract

Biofuels are becoming an increasingly important source of energy globally. The international biofuels industry experienced tremendous industry growth mainly driven by: increased energy demand and more specific petroleum prices, reliability of traditional crude oil exporters along with political motives, adverse pollution affects (Methyl tertiary butyl ether - MTBE) and more specific, emission gases from fossil fuels leading to environmental pressure for the use of cleaner burning fuels. By-products such as Distillers Grains from ethanol production can be a substitute for numerous protein rich raw materials such as oilcakes in animal feed rations which result in relative price changes and changes in consumption patterns of these raw materials. The possible impact on the animal feed industry is analyzed by using the BFAP and APR models. The results indicate that numerous relative price changes take place along with various changes in raw material consumption and that the total animal feed costs decrease with 2%.

1. Introduction and Background

In the past few years the world has witnessed substantial developments in the global production and production capacity of ethanol, these developments are mainly driven by: increased energy and more specific petroleum prices, reliability of traditional crude oil exporters along with political motives, and the reduction of emission gases leading to environmental pressure for the use of cleaner burning fuels. Thus biofuels are becoming an increasingly important source of energy globally. For the purpose of this study, the focus will only be on ethanol production.

When producing ethanol, the by-product, Dried Distillers Grains with Solubles (DDGS), which is rich in protein and can be used in animal feed rations (Dunn, 2005). DDGS can be a substitute for numerous protein rich raw materials such as oilcakes in animal feed rations which then result in relative price changes.

Currently biofuels are not yet a reality in South Africa, mainly because of barriers to entry such as high feedstock prices and the delayed biofuels industrial strategy. The biofuels industrial strategy draft was approved by Cabinet in December 2007 after a two- year consultation process.

The main objective of this study is to investigate the likely impact of maize based ethanol production from maize on the animal feed industry. This will be undertaken by making use of a two base scenarios that incorporates a combination of key drivers and uncertainties into the modelling framework. This is followed by an analysis to test the impact of ethanol production on the animal feed industry.

2. Problem statement

The South African ethanol production will likely have numerous effects on markets such as the animal feed industry, which will mainly be influenced by the feedstocks to be used and compulsory blending percentages to be implemented.

Because of the near complete fermentation of starch, the remaining protein, fat, minerals and vitamins increase approximately three-fold in concentration in DDGS, compared to their original levels found in maize (Dunn, 2005). DDGS is high in protein, 27%, according to analysis by Dunn (2005), and can therefore substitute other protein rich raw materials such as various oilcakes and hominy chop.

Various international studies including: Reilly and Paltsev (2007); Dixon, Osborne, and Rimmer (2007); Banse *et al.* (2007), Birur *et al.* (2007), and Hertel *et al.* (2008) used general equilibrium models to address the economy-wide and environmental consequences of producing biofuels on a large scale. These studies mainly argue that since biofuels are mostly produced from agricultural sources, their effects are largely felt in agricultural markets with major land use and environmental consequences. Almost all of these studies have over-emphasised the impact of biofuels on agricultural markets due to the fact that they have ignored the role of by-products resulting from the production of biofuels. The inclusion of DDGS into models is very important; Tokgoz *et al*. (2007) and more recent authors such as Taheripour, Hertel and Tyner (2008) and Babcock (2008) have, for example, incorporated DDGS as a substitute for various raw materials and shown that the inclusion of DDGS in their models significantly changes the results.

It is clear from the literature that DDGS is an important part of the ethanol industry but all of these studies only investigate the impact on the agricultural sector and ignored the likely impacts on other related sectors such as the animal feed industry. This paper focuses on the impact of ethanol production on the animal feed industry.

3. Methodology and data used

In order to quantify the likely impact, two models are used. The first model is the Bureau for Food and Agricultural Policy (BFAP) model. The BFAP model projects a set of equilibrium prices for 2015 under a certain set of assumptions. These equilibrium prices are incorporated into the Agricultural Product Requirement (APR) model where the changes in animal feed consumption are quantified.

3.1 The BFAP model

In order to estimate the raw material equilibrium prices for 2015, the BFAP model will be used. The BFAP sector model is a dynamic system of econometric equations, which has the ability to model cross-commodity linkages (Meyer *et al*, 2008). A set of equilibrium prices are generated by the BFAP sector model under the scenarios that is explained below which are used in the APR model. There are a number of underlying drivers and uncertainties in the scenarios developed for the purpose of this study.

3.1.1 Scenario

Drivers are factors or a combination of factors of which the direction of change, magnitude of change, as well as the impact of change, is quite predictable. The following drivers were used in order to develop a scenario: Legislation, population, urbanization, disposable income, local profitability of the production of protein, biofuels, oilseed markets, the crude oil market as well as the exchange rate (macro economy). These drivers are explained in more detail in Table 1. A key uncertainty is a factor or combination of factors of which the direction, magnitude and impact of change is totally unpredictable. The following uncertainties are identified in order to develop the scenario: biofuels, legislation, crude oil, lack of electricity supply as well as macro economic shocks in the USA, EU, China, and Japan. The likely effects of the uncertainties are explained in more detail in Table 2.

Table 1: Scenario 1 Drivers (2007 – 2015)

Driver	Effect
Legislation	Balance between government policies on job creation vs food inflation
	Department of Trade and Industry (DTI) and National Department of Agriculture (NDA) main Government institutions that will determine Government policy that affects agriculture.
	Import tariffs on all meats remain in place
	Land Reform will continue at a slow pace.
Population	Continuation of legal and illegal immigrants with a small positive growth rate of local population causes population to grow.
	The impact of HIV AIDS is smaller than anticipated, due to the effective use of antiretroviral drugs
Urbanisation	Urban areas are associated (expected) with a higher level of income. Driving the food consumer to more value added goods.
	The presence of urbanization is expected -starchy staples to more value added goods.
	Urbanisation has a dampening effect on the growth of the population
Disposable income	Slow pace of job creation will continue
	Expenditure patterns of black middle income vs “fat cats” can shift
	New credit laws & higher interest rates will not negatively affect the consumption of basic food items.

Profitability of protein production	Maize and soya price ratio is critical.
	Yields maize vs soya increases. Both continue past trends
	The oil fraction of soya beans remains constant
	Rebate of the duty on soya beans for the extraction of soya bean oil to be used in the production of biodiesel is in place
Biofuels	Government commitment to meet Kyoto Protocol.
	Biofuels "drop in the bucket" of global energy market, huge impact on agricultural commodities.
	Biofuels in SA will not have a positive impact on the labour market, which Government is hoping for.
	Technical constraints of blending ethanol into petrol are not experienced when blending biodiesel into diesel.
Oilseed market	World demand for oilseeds will continue to outstrip world supply
	Expansion of soya bean crushing facilities will remain and soya beans will trade closer to import parity levels.
Crude oil market	Political instability in the Middle East will keep on putting upward pressure on oil prices
	Whereas the Chinese economy will grow, but at a decreasing rate, the Indian economy will grow at an increasing rate.
Macro economy	Strong growth in local economy will support the Rand and attract more foreign direct investment.
	Gold prices remain high
	US economy under pressure while Japan recovers.
	EU economic recovery not as fast as hoped for.

Table 2: Uncertainties of Base Scenario (2007-2015)

Driver (category)	Uncertainties
Biofuels	Will licensing for the production of biofuels be implemented?
	SASOL plant of 600 000 tons soya beans to produce 400 000 tons of cake and 200 000 tons of oil.
	Will all the feedstock for biofuels be sourced locally?
	Government strategy on blending rates, tax incentives and subsidies, tariffs on imported biofuel and the price formulation of biofuel
Legislation	Political instability of ANC vs SACP/Cosatu
	Social policies of a "Welfare State" – grants and food stamps that can increase the demand for protein

Crude oil	The discovery of an alternative source for crude oil.
Lack of electrical supply	Decrease in production
Macro economic shocks – USA, EU, China, Japan	Shocks occur such as a dramatic downturn in markets, world economic trends would change due high energy prices and high interest rates.

3.1.3 Impact of ethanol production

The impact of ethanol production is quantified by means of adding an additional scenario such as scenario 2. This scenario has the same drivers and uncertainties as scenario 1, with the only difference being the additional scenario excludes ethanol production.

3.2 APR model [1]

To quantify the raw material substitution with DDGS included as a raw material, the APR model developed by Briendenhann (2001) is used. This model is a linear programming feed formulation model that minimises the total animal feed cost in South Africa given the availability of raw materials and their corresponding prices. The demand for animal feeds is taken into account by the model, and the number of animals that need to be fed based on the nutrient requirements of those animals and their feed conversion ratios is determined. Imports and exports of raw materials are further determined by domestic availabilities of raw materials (Briedenhann, 2001).

An annually updated APR model calculates the total national animal feed demand based on the South African and the national human per capita consumption of

1 The authors would like to thank Dr Briedenhann for his valuable contribution in understanding the APR model.

animal products given the biological performance data of the animal species involved.

3.3 Data used

The data and sources thereof used as inputs into the BFAP and APR models are discussed in the following two sub-sections.

3.4.1 Data for the BFAP model

In order to simulate the equilibrium prices and forecasts with the BFAP model, a baseline is used for the 2006/2007 year, (i.e. April 2006 to March 2007) based on the AFMA (2007) chairman's report. This data is used as a baseline to simulate the scenario and to generate price projections for 2015. The most important base line data is reflected in Table 3 and Table 4.

Table 3: SA raw material prices for 2007

Raw material	***R/ton***
Maize Germ	1000
Full fat Soya	2275
Barley	1650
Maize Yellow	1261
Sorghum	1000
Soya Hipro Oilcake	2080
Sunflower Hipro Oilcake	1350

Source: AFMA (2007) and own calculations

Table 4: Base factors used for 2007

Base factors	***Value***
Per capita consumption chicken	25.39
Per capita consumption cattle beef	16.13
Per capita consumption milk	44
Per capita consumption eggs	6.99
Per capita consumption pork	3.78
Per capita consumption mutton	3.22
Population (millions)	47.35
Exchange Rate (Rand to US$)	7.16

Source: AFMA (2007) and own calculations

3.4.2 APR model

The different raw material prices used in the APR model for the year 2015 is simulated by the BFAP model and these data forms part of the BFAP results. These prices are in a state of equilibrium for 2015 after the inclusion of DDGS into the industry. In order to quantify the changes with the APR model, several base factors such as per capita consumption of various products, population and the exchange rate must be accounted for.

An important variable is transport costs, mainly because of high petroleum prices. Table 5 reflects these transport costs used for the year 2015. The prices are calculated with the help of the crude oil price calculated by the BFAP model. For scenario 1 a crude oil price of $145/barrel is simulated with the help of the BFAP model.

Table 5: Transport costs for Scenario 1

Region	*Destination*	*R/ton*
Cape, KwaZulu Natal, Interior	Within region	R 340
Interior	Cape	R 1 275
Cape	KwaZulu Natal	R 1 615
KwaZulu Natal	Interior	R 645

Source: Own calculations

4. Results

The changes in the animal feeds cost as well as raw material consumption resulting from the scenarios are reported in this section along with the changes in the total animal feed costs.

4.1 BFAP results

The BFAP model simulates the equilibrium prices for 2015; with these simulated prices the effect of ethanol production on various animal feed raw materials can be quantified. In Table 6 the prices simulated with the BFAP model with Scenario 1 and 2 is reflected. The raw material prices simulated in Scenario 1 for DDGS, Soya Hi pro, Sunflower Hi pro and Full fat Soya are R 1 954/.ton, R 4 303/ton, R 3 346/ton, R4 984/ton respectively. With the exclusion of ethanol production the raw material prices simulated in Scenario 2 for Soya Hi pro, Sunflower Hi pro and Full fat Soya are R 4 650/ton, R 3 480/ton and R 4 986/ton respectively. This means that ethanol production have an increasing effect on the Yellow maize price and a decreasing effect on the Sunflower Hi pro and Soya Hi Pro prices.

Table 6: Predicted Raw material prices for 2015 with scenarios 1 and 2

	Scenario 1		**Scenario 2**	
Raw material	**Local price (R/ton)**	**Imported price (R/ton)**	**Local price (R/ton)**	**Imported price (R/ton)**
DDGS	1954		-	
Fish Meal Hi pro	8372		8372	
Full fat Canola	5789		5791	
Full fat Soya	4984		4986	
Barley	4105		4105	
Maize Yellow	2417	3772	2248	3772
Sorghum	1912		1898	
Soya Hi pro Oilcake	4303	5602	4650	5602
Sunflower Hi pro Oilcake	3346	3236	3480	3236

4.2 APR results

With the introduction of DDGS resulting from the production of ethanol, substitution between raw material consumption as animal feeds takes place. This substitution is highly dependent on the price of the DDGS as well as the availability of DDGS.

All the raw material consumption substitution results for both the scenarios are illustrated in Table 7. With the introduction of ethanol production the following substitution takes place:

- Yellow maize consumption decreases with 3%

- Sunflower Hi pro and Fish meal consumption decreases 5% and 1% respectively.
- Soya Hi pro and Lucern consumption decreases with 8% and 27% respectively.

According to the results mentioned above, it means that ethanol production has a decreasing effect on the consumption of raw materials such as Yellow maize, Sunflower Hi pro, Fish meal, Soya Hi pro and Lucern. In other words the demand for these raw materials as animal feed decreases.

Table 7: Consumption and substitution of raw materials in Scenario 1 and 2.

Raw materials	Base year	1	% change from base	2	% change from base	% change from base 2 - 1
	tonnes			tonnes		
Maize Yellow	4288915	7202866	68%	7461714	74%	-4%
Sorghum	7000	9240	32%	9240	32%	0%
Maize Germ	610400	763000	25%	763000	25%	0%
Wheat Middlings	793898	1192463	50%	1192463	50%	0%
Maize Gluten 20	116756	154118	32%	154118	32%	0%
Maize Gluten 60	26040	34373	32%	34373	32%	0%
Cotton	210178	373351	78%	372902	77%	0%
Sunflower HiPro	351190	656294	87%	659450	88%	-2%
Soya	255640	303700	19%	303700	19%	0%
Fishmeal	29162	40666	39%	41142	41%	-3%
Soya HiPro	896563	1059604	18%	1154315	29%	-10%
Lucern	400108	191187	-52%	262418	-34%	-38%
Molasses	374278	507000	35%	506404	35%	0%
DDGS	0	281546		0		
TOTAL	**9667137**	**14166889**	**47%**	**14121555**	**46%**	**0%**

In terms of total animal feed cost an increase of 2% from scenario 1 to 2 is shown which is an amount of R 894 997 969. This means that with the introduction of DDGS into the animal feed industry, the costs of animal feed decreases, and ethanol has a total animal feed cost decreasing effect on the animal feed industry.

5. Conclusions

If ethanol is produced in South Africa various changes within the animal feed industry will take place, including animal feed raw material price reactions, substitution between consumption of different raw materials and changes in feed costs.

Scenario 1 produces 281 000 tonnes of DDGS and sells for R 1954/ton. With the introduction of the DDGS into the animal feed industry the Yellow maize price increases with 7% while the prices of Sunflower Hi Pro and Soya Hi Pro decreases respectively by 4% and 8%. This means that with the introduction of DDGS the demand for Yellow maize as animal feed and various other protein rich raw materials decreases.

With the introduction of DDGS into the animal feed industry the Yellow Maize consumption as animal feed decreases with 4% while the consumption of Fishmeal, Soya Hi pro and Lucern decreases with 3%, 10% and 38% respectively. The Yellow maize consumption decreases mainly because DDGS is a cheaper protein than Yellow Maize. Because South Africa is a net importer of protein animal feed, the consumption of various other raw materials is also decreasing, this is mainly due to the fact that DDGS is more price competitive and is substituting these raw materials. Lucern is not imported but being rich in protein, it remains a close substitute for DDGS. Another contributing factor is the digestibility of DDGS.

The total animal feed cost decreases with 2% when ethanol is produced. This means that ethanol production have a decreasing cost effect on the animal feed industry. This is a result of DDGS substituting expensive imported protein rich animal feeds.

With the ethanol production figures of Scenario 1 there is not an enormous effect on the animal feed industry. In terms of the changes in raw material price shifts it is only small percentages that change and not anything major. With the raw material consumption substitution the same effect as with the raw material price shifts is found and no significant changes take place, except for Lucern consumption which decreases with 38%. In terms of the total animal feed costs the animal feed industry will not feel a 2% change and the conclusion is made that the ethanol production will have an affect on the industry but not a noticeable effect. If the production of ethanol increases, a more notable effect will be seen.

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Additional info

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2. Affirmation statement

I DB Strydom confirm that the work done in this paper is original research carried out by the specified authors and that this research was never published or presented elsewhere.

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