THE EXPECTED CONSUMPTION OF PROTEIN FEED IN SOUTH AFRICA BY 2020

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The consumption of animal products in South Africa is projected to 2020 and used to derive protein feed usage. A spreadsheet model, developed for this purpose, has the following novel features:- it is interactive and readily allows for scenario analysis; the price of protein is endogenous in the South African model as it is generated by an international model; income elasticities of demand are permitted to decline with GNP growth; it incorporates estimated rates of technological progress in livestock production, and predicts the resulting real price change. Total protein consumption is projected at 1.54 million tons by 2010, a 24% increase from 2000, and 1.96 million tons by 2020, a 58% increase from 2000, under base population growth and low income growth. Broiler, egg and pork product prices (projected to decline in real terms because of expected technological advances) contribute to increasing protein usage even in the absence of significant real income growth rates. Population growth remains the most important demand driver and scenario analysis reveals that alternative population growth rates impact significantly on projections. The negative effect of HIV/AIDS on population growth and the subsequent restriction on potential protein use is evident.

1. INTRODUCTION

South African imports of protein feed (oilcake or meal) increased 210% from 1990 to 1998/1999. Over that same period local production increased by only 14% and imported protein feed now accounts for over 50% of local requirements at an estimated annual import cost of R1 billion. Most of this oilcake is soymeal for use in the poultry industry for broiler and breeder rations. Furthermore, international projections to 2020 (Paper 1) reveal that the world price of protein meal is unlikely to decrease significantly in real terms, limiting the possibility of cheap imports. Estimating future South African consumption under alternative assumptions of expected future economic and social conditions will help guide decisions affecting future production capacity.

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The Protein Research Trust (PRT) has requested that the international protein market and its impact on the South African (SA) market be studied. Of particular interest is the impact of changes in vital decision variables (such as population and real income growth) on future SA consumption. A model that allows for "what if" analysis and readily provides results for different scenarios is, therefore, valuable. The objective of this research is to develop an interactive spreadsheet model capable of projecting protein feed requirements to 2020.

Methodological development of the model builds on work by Nieuwoudt (1998a,b). The operation of this earlier model is improved by the following features in the upgraded model:- (a) it is interactive and readily allows for scenario analysis; (b) the price of protein is endogenous as it is generated by an international model; (c) income elasticities of demand are permitted to decline with GNP growth; and (d) estimated rates of technological progress in livestock production are used to predict future real price trends.

In this paper an earlier model is first reviewed, then the methodology involved in projecting demand is presented with projected demand indices. An explanation of how livestock product prices are affected by technological advances follows. Protein consumption is then derived and results from the model are given for various scenarios. Discussion of the main findings and implications to the PRT and policy makers concludes the paper. All references to income growth and price are in real terms.

2. BACKGROUND TO THE STUDY

In response to PRT requests, the model developed by Nieuwoudt (1998a,b) was reviewed to determine how improvements could be made. His high-income growth projections were 2.8% lower and low-income growth projections 9.4% lower than actual usage in 2000 (Table 1). Real per capita GDP growth rate assumptions applied in the high-income scenario (although conservative at the time) were considerably higher than experienced between 1995 and 2000. Data from SARB (2000) shows annual per capita GDP growth of between –1.0% and 1.9%[3], while initial high-income growth assumptions assumed per capita GDP growth of 1.5% for whites and 2.75% for other race groups. Yet even projections made under a high-income growth scenario underestimated protein consumption growth.

[3] *Per capita growth calculated using population growth rates from STATSSA(2000)*

Table 1: Actual protein consumption compared to predictions by Nieuwoudt for 2000 (tons)

	Prediction (High Income Growth Scenario)	Prediction (Low Income Growth Scenario)	Actual
Total*	1,210,278	1,127,988	1,245,320

Source: Nieuwoudt (1998b) and Griessel (2000).

Nieuwoudt (1998b) assumed price decreases of 20% (0.7% annually) for poultry, 15% (0.6% annually) for pork and 25% (0.15% annually) for eggs from 1995 to 2020. Actual retail prices of chicken, pork and eggs declined by about 24% (7% annually), 9.8% (3% annually) and 14% (4% annually)[4] respectively from 1996 to 1999 in real terms. It is therefore speculated that real price decreases in meat and protein meal contributed to increased protein usage (movement along the demand curve) despite minimal increases in GDP growth.

Internationally real prices of livestock commodities have declined since the 1970's (Delgado et al, 1999), therefore the new spreadsheet model takes into account the supply shifting effects of technology in an attempt to predict future price trends.

The low-income growth projections by Nieuwoudt (largely driven by population growth) are still relatively close to actual. Population growth is thus an important determinant of future demand and demographic assumptions, including the possible effects of HIV/AIDS, play an important role in future projections. Two alternative population scenarios are considered in section 6.

3. CONSUMPTION PROJECTIONS FOR LIVESTOCK PRODUCTS

Consumption of protein feed in South Africa was projected to 2020, by first projecting consumption of animal products and then deriving feed utilization from consumption of the final product, using 2000 as the base year.
In this study the consumption of all protein feed is projected and not the consumption of specific ingredients (e.g. soymeal). In the long-term, relative prices of major oilcakes are expected to move together because of substitutability between different oilcakes on the demand side. Using least cost formulations to determine projected consumption of specific ingredients (e.g. soymeal) thus has less value for long-run projections. Even maize and

[4] *Price data from SAMIC (2000)*

soybean prices move together in the long-term as they compete for similar resources (land). They are thus substitutes on the supply side, especially in the USA (a major exporter of these commodities). Fishmeal prices also tend to follow oilcake prices although price fluctuations are greater. However, internationally aquaculture uses most fishmeal and total fishmeal production is limited. It is unlikely that fishmeal usage will grow significantly, especially in the long-term.

3.1 Projecting demand for livestock products

The factors affecting demand in the model are expected population growth, income per capita growth and estimated income elasticities of demand. Estimated income elasticities for high-income groups are considerably lower than those for low-income groups, which can be expected to fall as incomes rise. A novel feature of this model is that income elasticities[5] are permitted to decline as incomes increase. A demand function estimated by Schroeder, et al (1995) that allows income elasticities to vary with income level is adapted for this purpose (Paper 1). Table 2 shows how income elasticites of demand for poultry are estimated to decline from 2000 to 2020 for each population group assuming the high per capita income growth rates shown in Table 3.

Table 2: Income elasticities of demand for poultry, assuming high per capita income growth

	Asian	Urban Black	Rural Black	Coloured	White
2000	1.09	0.66	1.33	0.65	0.32
2020	0.91	0.55	1.27	0.54	0.32

Note: Income elasticities for all animal products are assumed to fall by the same percentage.

Demand for different commodities by each population group is estimated and then aggregated. Apart from population data for 1999 from STATSA (2000), population growth data from van Aardt et al (1999), which account for possible HIV/AIDS effects are used for the base scenario. van Aardt et al also present probabilistic projections, giving a high and low range, these projections are considered in later scenario analysis. Per capita expenditure by population group and product is from Martins (1999). Real income and population growth predictions as shown in Table 3 differ by population group and thus consideration is taken of differing social and demographic

[5] *The model allows income elasticities for Blacks, Asians and Coloureds to decline with rising income*

structures. Following Nieuwoudt (1998a), rural black population is assumed to remain constant.

Table 3: Projections of annual growth by population group as used in the model

	Asian	Black Urban	Black Rural	Coloured	White	Black Total	Total
Population Growth							
Base	0.72	2.28	0.00	1.01	0.02	1.19	1.04
High	1.24	2.96	0.00	1.52	0.65	1.68	1.54
Low (AIDS worst case)	0.09	1.01	0.00	0.37	-0.49	0.53	0.39
Real Income Growth							
High	2.8	2.8	0.8	2.8	1.5		
Low	1.0	0.0	-2.0	0.0	0.0		

Source: Adapted from Nieuwoudt (1998b) and van Aardt et al (1999).

Table 4 gives projected demand indices by product for 2010 and 2020. If low-income growth is assumed then positive demand shifts are attributable to population growth. The rate of population growth amongst the black population is highest. Therefore, products such as milk and eggs, where total consumption is accounted for mostly by the black population, are forecast to experience the largest increase in demand over time. Projected demand is lower for the more expensive meat products, which are largely consumed by the white population. However, high-income growth rates lead to large increases in demand for those products that are more responsive to income growth, such as eggs, beef, mutton and broilers.

3.2 Expected future demand, supply and prices of livestock products

It is assumed that the SA livestock product market approximates a competitive market and, therefore, expected shifts in future supply determine the equilibrium consumption. Supply of meat products will be comprised of both local meat production and imported meat products. However, only locally produced products will use protein feed in SA.

Future protein consumption depends on whether changes occur with respect to the base scenario (that is, whether more or less livestock products are imported or exported). Base scenario projections assume that imports and exports remain constant in absolute terms throughout the projection period.

The implicit (base scenario) assumption is that international and local technological developments occur at the same rate. If local producers lag behind international competitors, lower world prices will result in increased imports, unless higher tariffs are applied.

Table 4: Projected demand indices by product for 2010 and 2020, South Africa

	Low Income Growth		High Income Growth	
	2010	2020	2010	2020
Beef	109	111	132	162
Poultry	106	107	127	152
Pork	110	113	115	124
Mutton/Goat	109	112	131	161
Eggs	112	117	129	155
Milk	110	113	123	142

Note: Index is 100 in 2000. High and Low income growth rates are from Table 2.

Forecasting supply shifts is more difficult than forecasting demand shifts since the former depend upon technological changes in production and changing feed costs which are less predictable than demand shifters (e.g. population growth). For intensively produced products (e.g. poultry, pork and eggs), long run supply is assumed to be perfectly elastic (opportunity cost is assumed constant)[6]. Consumption is determined by using estimated price elasticities of demand to simulate the effects of future price trends. Beef and mutton consumption is determined by calculating the equilibrium intersection of estimated supply and demand curves.

Commodity prices are mutually determined and it is therefore appropriate to use total price elasticities, which account for changes in prices and quantities of other commodities (Buse, 1958), when estimating the quantity response. Total price elasticities of demand for livestock products are lower than the corresponding partial elasticities since the main interrelationships are substitute relations (Tomek and Robinson, 1990). Adam (1998) recently estimated conditional Slutsky price elasticities for beef, poultry, pork and mutton and these estimates are used in this study as a proxy for total elasticity. However conditional elasticities are expected to be smaller in

[6] *Expansion of the industry will have no effect on resource prices or, therefore, on production costs*

absolute terms than the corresponding unconditional estimates, since total expenditure on the group (meat products) is held constant[7] (Adam, 1998). Total price elasticities are thus taken as the average of those estimated by Adam (1998) and those used by Nieuwoudt (1998b).

In order to account for the income effect of changing commodity prices these elasticities are further adjusted using the following equation from Friedman (1962 page 55).

$$n_{XP} = -Kn_{XI} + \tilde{n}_{XP} \qquad (1)$$

where

n_{XP} = price elasticity of demand of the ordinary demand curve at point P for product X.
K = fraction of income spent on X
n_{XI} = income elasticity of X
$\tilde{n}_{XP}$ = price elasticity of demand of X if real income is held constant

Expenditure data from Martins (1999) are used to estimate *K*, income elasticities (n_{XI}) for each population group are weighted by group expenditure to obtain a single income elasticity estimate. Total price elasticities of demand, as estimated using the above technique, are shown in Table 5.

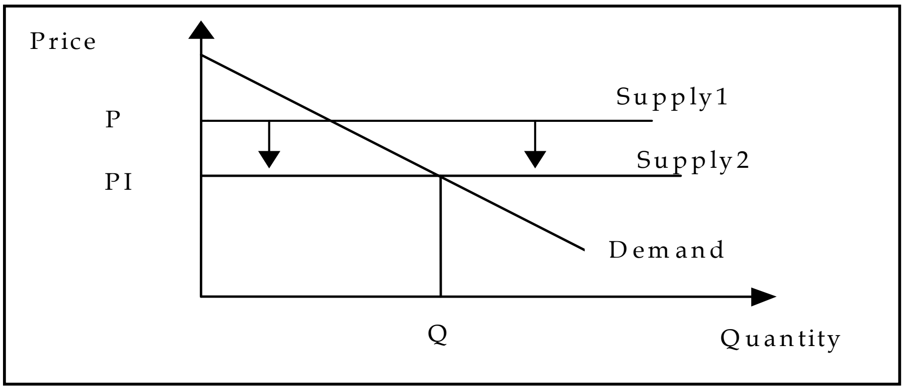
Table 5: Total price elasticities of demand used in the model

	Beef	Poultry	Pork	Mutton/Goat	Eggs	Milk
Elasticity	-0.82	-0.77	-1.05	-0.82	-0.3	-0.78

The broiler, egg, and pork sectors use protein feed intensively. After broilers, dairy consumes the most protein feed in absolute terms. Special care in analysing future prices of these products is necessary since movements along the demand curve (especially for poultry) have a significant effect on feed consumption. In Figure 1, the supply function of these factory type products (broiler, egg, pork) is shown as perfectly price elastic since specialized factors of production are absent. The supply function can however shift downward as a result of technological improvements. This shift is shown as a shift from the original price P to projected price PI. The major factors influencing local product prices are feed prices (feed is the major input cost), supply shifting

[7] *Conditional elasticities therefore reflect inter-group competition only, therby reducing the potential number of substitutes*

technological improvements and import prices. Technology and feed prices are taken into account when estimating future price as described below, a no tariff scenario is presented to illustrate the effect of import price changes.



Note: PI is the estimated future price index. Projected consumption is at point Q.

Figure 1: Price elastic supply of product intersecting demand curve

Poultry

Historically, improvements have been achieved in time taken for broilers to reach slaughter weight and in the production of breast meat per kg of a whole bird. For example, the time taken to produce a broiler of specified slaughter weight has decreased from 84 days in 1950 to 36 days in 1999. Technological progress of this nature contributed to a 5% annual growth in world production and price decreases of 4% annually from 1990 to 2000[8]. Future advances are possible although the rate of improvement (especially in terms of days to slaughter weight) is unlikely to be as high (Gous, 2001; McKay, 2000).

Table 6 shows data for three possible measures of technological improvement in broiler production including days to slaughter, grams of breast meat per kg of whole bird, and kg of feed required per kg of whole bird. In each case technology is expected to improve production, albeit at a declining rate (Figure 2). Compound growth rates given by functions (a), (b) and (c) (Table 6) show rates of technological growth of between 1.35% and 3.25%. Trends estimated by these functions suggest future progress will lead to a continued reduction in days to slaughter and broilers will contain a higher percentage of breast meat. For example, if current trends continue, by 2020 a broiler with 452 grams of breast meat will be produced in 26 days. Function (a) (Table 6),

[8] *Data are from FAO (2000), price is taken as import value/import quantity*

which predicts days to slaughter, is used to calculate a technology index that estimates the future effect of technology[9] as follows:

$$TI_{By} = (1+tgr_{B})^{n} \quad (2)$$

where

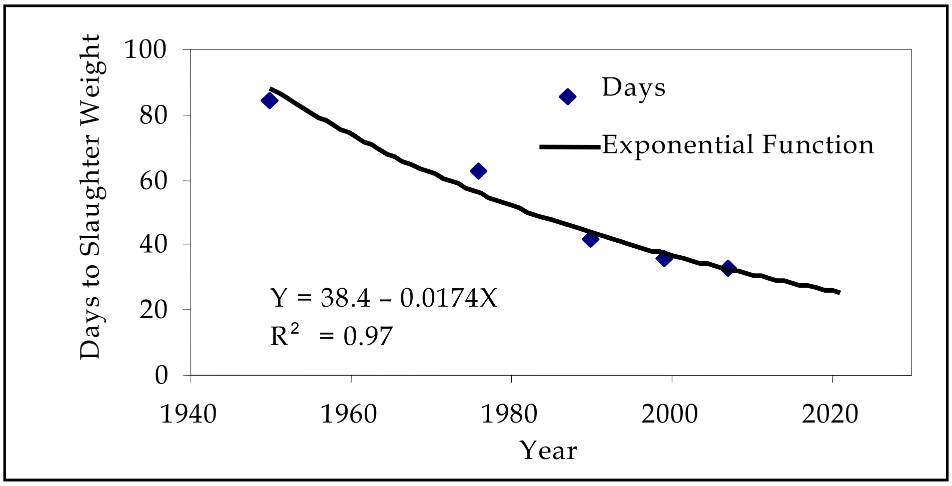
TI_{By} = technology index for broiler production in year y.
tgr_{B} = compound growth rate for broiler production resulting from genetic change.
n = the number of years from base year to year y.

Table 6: Technology related improvements in poultry production

Days to Slaughter Weight		**Grams of Breast Meat per Kg of Chicken**		**Kg of Feed required for 1 Kg of Breast Meat**	
Year	**Days**	**Year**	**Breast Meat (g)**	**Year**	**Feed (Kg)**
1950	84	1976	250	1976	20
1976	63	1999	340	1999	10
1990	42	2007	380	2007	7
1999	36	-	-	-	-
2007	33	-	-	-	-
Function (a): LnDays = 38.4 -0.0174Year		**Function (b)**: LnDays = -21.11 + 0.0135Year		**Function (c)**: LnDays = 68.29 - 0.033Year	
Compound Growth: -1.72%		Compound Growth: 1.37%		Compound Growth: -3.25%	
Prediction in 2020: Fewer days to slaughter (26 days to slaughter at current trend).		Prediction in 2020: More breast meat (452 grams of breast meat at current trend).		Prediction in 2020: Less feed per kg gain (5 Kg of feed for 1Kg of breast meat at current trend).	

Source: Own Calculations from Gous (2001); McKay (2001).
Note: Projections to 2007 are made by McKay (2001).

[9] *Function (a) is chosen because: a) technological progress in poultry production is often expressed in terms of declining production time. b) the growth rate of 1.72% lies between 1.37% and 3.25%*



Source: Raw data obtained from Gous (2001); McKay (2001).

Figure 2: Current and projected days to slaughter weight for broilers, 1950 to 2020

Eggs

During 1961/65 to 1990/94 real egg prices in SA declined by 51%. Technological advances in egg production are unlikely to continue at the rate that contributed to this price fall. However, a declining real price trend is expected and it is assumed that annual prices will fall by 1.473% annually (Nieuwoudt, 1998b).

Pork

From 1990 to 2000 world pork production increased 2.7% annually and prices declined by 4%[10] annually. An econometric study by Marsh (1999) estimates that in the USA from 1980 to 1997 13kg of the 21kg increase in slaughter weight could be attributed to technology effects. Hall (2001) currently observes annual improvements of about 2% in a nucleus herd through genetic improvement. Future improvements are likely as researchers learn more about animal requirements, improve genetics and feeding strategies and make use of simulation models (Ferguson, 2001).

Table 7 shows potential for lean tissue growth in pig production. Nutrient conversion rates remain constant while lean growth is forecast to increase by about 1.8% annually. A technology index is calculated from a growth model, as in the case of broilers (equation 1).

[10] *Data from FAO (2000), price is taken as import value/import quantity*

Table 7: Genetic potential for lean tissue growth for pork 1999 to 2010 and required nutrients

Year	Lean Growth Rate (g/day)	Requirement for Energy (MJ DE / day)	Requirement for Lysine (g / day)	Requirement for Protein (g / day)
1999	450	28.0	24.0	400.0
2001	470	29.2	25.1	417.8
2005	510	31.7	27.2	453.3
2010	560	34.8	29.9	497.8

Source: Hall et al 2001.

Dairy

Data showing technology related improvements were less readily available for dairy products. Rae and Hertel (2000) report feed conversion ratio improvements of 0.6% per annum in the US. The technology index for dairy is calculated in the same manner as for pork.

3.3 Projected future consumption of livestock products

For poultry, dairy and pork production a future price index is calculated as:

$$PI_{py} = TI_{py} * IPI_y \quad (3)$$

where

PI_{py} = price index for product p in year y.
TI_{py} = technology index for product p in year y.
IPI_y = international protein price index (which feeds through from the international model or can be independently estimated).
For eggs:

$$PI_{eggs} = (1.0-0.0147)^n *IPI_y \quad (4)$$

The effect of projected prices on consumption is calculated as:

$$FCon_p = PE_p *(PI_p - 100) * DDF_p \quad (5)$$

where

$FCon_p$ = future consumption index of product p in year y.

PE_p = Price Elasticity of demand for product p
DDF_p is the demand index for product p (refer Table 4)

Comparing consumption indices with demand indices shows the effect of expected price trends. Real prices for poultry, pork and dairy are forecast to decrease and, hence, future consumption of these products is expected to increase more than predicted based on demand shifters alone.

Table 8: Livestock consumption indices assuming constant world price of protein meal and livestock products

	Low Income		High Income	
	2010	2020	2010	2020
Beef	103	104	110	117
Poultry	119	131	143	186
Pork	129	149	135	163
Mutton/Goat	102	103	106	110
Eggs	117	126	134	167
Milk	115	124	129	155

Beef and Mutton

Beef consumption for 2020 assuming base population growth and alternative income growth scenarios is estimated as:

Supply Function: P = -100+2q
Price Elasticity of Supply = 0.5 (Nieuwoudt 1998b)
Demand Function 2000: P = 222 –1.22q (base scenario)
Demand Function 2020: P = 222 – 1.17q (low income growth)
Demand Function 2020: P = 222 – 1.04q (high income growth)
Price Elasticity of Demand = -0.82 (Appendix **Table B**).

Consumption indices in 2020 for low and high income-growth scenarios are estimated as 104 and 117 respectively.

4. PROJECTING FUTURE PROTEIN CONSUMPTION

For products requiring intensive feeding, (i.e. pork, poultry and eggs) the product consumption index (Table 8) was multiplied by the base protein usage for each product. Since beef, sheep and milk are partly produced extensively, the feed consumption for these products is estimated from that portion of the final product requiring intensive feeding as follows:

Beef

In 1998/1999, 518000 tons of beef were produced in SA while 70% of beef slaughtered are fed in feedlots. Cattle are kept on average for 3 months in a feedlot, while the average age of the total herd is 2 years. In 1998/99 an estimated 90650[11] tons of meat was produced in feedlots. Assuming all increased meat production occurs in feedlots the protein consumption index (PconI) for Beef is calculated as:

$$PconI_{beef} = (Fcon_{beef} /100* 518000)-518000)/90650 +1)*100 \quad (6)$$

Therefore, a 4% increase in beef consumption (beef consumption projection, $Fcon_{beef}$, for low-income growth is 104) will lead to a 23%[12] increase in feedlot feed use. Base protein consumption data are aggregated and projections therefore assume similar consumption growth for sheep and beef. This assumption is unlikely to impact significantly on projections as beef and sheep production use relatively small amounts of oilcake. Furthermore, most sheep are produced under extensive grazing conditions.

Milk

One litre of milk production requires 0.45kg of feed, 12.5% of which is oilcake. In 1998/1999, 2022 million litres of milk were produced and an estimated 341365 tons of protein feed used. Protein feed required is calculated as:

$$(FCon_{milk}/100*2022*10^6- 2022*10^6)*0.45*0.125/1000) \quad (7)$$

5. RESULTS AND DISCUSSION

Under base population growth, assuming the international protein price remains constant (100), annual meal usage is forecast to grow at 1.06 % annually under low-income growth and 2.30% annually under high-income growth (Table 9). At these growth rates protein consumption will increase by 0.29 million tons under low-income growth and 0.72 million tons under high-income growth.

Annual growth in feed use by the poultry (broilers) sector is high (Table 10) because of relatively large price decreases for poultry, consequently the

[11] *3/12*0.7*518000 = 90650*
[12] *(1.04*518000-518000)/90650 = 23%*

poultry sector is forecast to increase its share of total protein meal consumed. Growth in pork production is high because expected technology adoption contributes to a 25% decrease in expected pork price. Historically per capita pork consumption has remained reasonably constant, if future technology affects are assumed to have no impact on consumption, forecasts for total protein consumption fall by about 2% to 3% at low and high income growth respectively.

Table 9: Estimated consumption of protein feed in South Africa for different scenarios under low and high income growth (2010 and 2020)

Scenario	Low Income Growth				High Income Growth			
	2010	2010	2020	2020	2010	2010	2020	2020
	Protein Feed (million Mt)	Annual Growth (%)	Protein Feed (million Mt)	Annual Growth (%)	Protein Feed (million Mt)	Annual Growth (%)	Protein Feed (million Mt)	Annual Growth (%)
Base Scenario[1]	1.43	1.40	1.54	1.06	1.62	2.65	1.96	2.30
High Pop. Growth	1.59	2.49	1.83	1.93	1.80	3.72	2.32	3.15
Low Pop. (AIDS worst case)	1.34	0.75	1.43	0.68	1.52	2.00	1.82	1.92
International Link[2]	1.44	1.44	1.56	1.14	1.62	2.69	1.99	2.38
International Link [3]	1.43	1.36	1.43	0.69	1.61	2.60	1.82	1.91
No Tariff	1.31	0.47	1.40	0.58	1.44	1.48	1.72	1.63
FCR Improvement[4]	1.35	0.85	1.37	0.49	1.53	2.06	1.73	1.66
No technology effect on Pork.	1.41	1.22	1.49	0.91	1.59	2.48	1.91	2.16

Notes: 1. International protein price assumed to remain constant. 2. Link to international model with linear supply growth. 3. Link to international model with 3% growth in supply. 4. Uses FCR index described in 6.3.

The effect of increased beef consumption on beef sector protein use is amplified because of the assumption that additional beef is produced intensively. Protein consumption increases considerably for eggs and beef/sheep production under a high-income scenario, demonstrating the elastic response of these products to rising incomes (Table 10).

If the long-term growth in world protein supply of 3% is maintained, world prices are forecast to decrease 4% by 2020. Linking to the international model in this case leads to projections that are about 1.5% greater than base scenario forecasts. If international protein meal supply is assumed to increase linearly, international price in 2020 is forecast to increase by 22% and projections for local growth are curbed.

Table 10: Protein usage by product in 2000 and 2020 at high and low income growth rates (Base Scenario)

Product	2000	2020	
		Low	High
Beef	67	83	132
Poultry	386	504	717
Pork	118	175	192
Layers	151	190	251
Dairy	341	368	404

6. ALTERNATIVE SCENARIOS

Due to the uncertainty of assumptions in the earlier analysis, alternative scenarios were simulated.

6.1 Tariff elimination

The SA livestock industry is currently protected by tariffs (Table 11). If these tariffs are eliminated livestock imports are expected to increase relative to local production. The impact of tariffs on displacement of local production depends on price elasticities of supply of the product in question. Tariff elimination is thus simulated by multiplying the estimated price reduction by estimated price elasticities of supply. For example, assuming an unprotected international price of 100 and tariff of 40, the protected local price is 140. Eliminating the tariff means that local prices fall from 140 to 100, the international price index, a decline of 29% (Table 11). Own projections indicate that if tariffs are eliminated, projected protein use is expected to be 1.4 million tons for the low income growth scenario and 1.72 million tons for the high-income growth scenario. Protein use is thus 9% to 12% lower than the base scenario if tariffs are eliminated.

The above simulation may underestimate the effect of reduced tariffs on the poultry industry. American consumers place a high value on chicken breasts whereas other chicken cuts can only be sold at low prices in the USA. Recently, (October 23, 2000) chicken legs could be imported at R4.78 (excluding all tariffs), a price against which local producers cannot compete. An additional R2.20/kg to R2.40/kg duty above the basic R2.20/kg tariff is levied on certain USA poultry cuts (depending on exporter). The effective tariff is therefore close to 135% for some cuts (Coetzee, 2000). Eliminating these duties would expose the local broiler industry to cheaper imports potentially resulting in large reductions in local production.

Table 11: Impact of eliminating import tariffs on local production of livestock products

Livestock Product	International Price Index (no tariff)	Local Price Index (with tariff)	Price Fall If No Tariff (%)	Price Elasticity of Supply	Impact on Local Production Following Elimination of Tariff (% change)
Beef	100	140	29	0.50	14.3
Mutton	100	140	29	0.25	7.1
Chicken	100	127	21	0.90	19.1
Pork	100	115	13	0.60	7.8

Notes: Tariffs are the maximum allowed by the World Trade Organisation.

6.2 Population Growth: The potential impact of HIV/AIDS

Van Aardt (1999) et al present population projections that they consider the most likely, but point out that these projections are subject to numerous uncertainties. They therefore present a probabilistic projection giving an estimated upper and lower limit to projections. Because of the importance of population growth on SA protein consumption, these limits are used as high and low population growth scenarios.

The high population projections are close to those used by Nieuwoudt (1998a) and would apply if for example HIV/AIDS impacts are vastly reduced by medical and behavioural factors[13]. The low projections can be considered as a worst case HIV/AIDS scenario. Alternative projections by USCensus (2001), which show negative population growth from 2004, were also considered but appear unlikely when compared to van Aart et al's (1999) low projections. Protein consumption is 7% lower and 19% higher under low and high population growth respectively. It likely that HIV/AIDS will impact negatively on economic growth (Bonnel, as cited in UNAIDS, 2000). However, the extent of this effect in SA is not known and hence low-income growth rate

[13] *The high population growth projections can be taken as an estimate of population growth without the negative effects of HIV/AIDS*

projections of 1.43 million tons by 2020 should be considered a worst case HIV/AIDS scenario.

6.3 Improved feed conversion

Future technological progress may improve feed conversion ratios (FCR) meaning that less feed will be required for a given amount of product. Large FCR improvements in poultry production are unlikely (Gous, 2001) as current nutritional technology is considered close to optimal. Linear FCR improvements are possible for pork production (Ferguson, 2001), although specific estimates are difficult to obtain and the rate of genetic improvement in feed efficiency can be expected to slow (Hall et al, 2000). Nevertheless, the impact of improved feed conversion can easily be assessed using the model as discussed below.

Briedenhann (2000) assumes linear FCR improvements for broiler production. A FCR index constructed from his data shows an annual decrease of about 1.15 index points. Scenarios of various improvements in FCR can be considered by adjusting the PconI as follows:

$$\text{FCR index} / 100 * \text{PconI} \qquad (8)$$

Using the FCR indices for pork and poultry reduces protein use projections for 2020 by 11% amounting to 1.37 million tons (low income growth) or 12% amounting to 1.73 million tons (high income growth).

7. COMPARISON WITH OTHER PROJECTIONS

A comparison of own projections with other sources is shown in Table 12. Nieuwoudt assumed that tariffs will be phased out by 2020. His projected protein consumption was similar under low income growth and 0.36 million tons higher under high income growth in comparison to own projections assuming tariffs are eliminated (Table 12). Briedenhann's (2000) projections are similar for base and low population growth.

8. CONCLUSION

An interactive spreadsheet model capable of projecting protein feed requirements to 2020 has been developed. Innovative features of the model include; an endogenously determined international protein price, income elasticities of demand decline with GNP growth, and estimated rates of technological progress in livestock production that are incorporated and used to predict price changes. Methodologically, the model is based on earlier work by Nieuwoudt for the PRT. However, the spreadsheet application enables easy scenario analysis and is thus useful for investigating the impact of changes in uncertain parameters such as population growth, income growth, elasticities and technology effects.

Table 12: Comparison of own projections with other projections of protein consumption to 2020

	Low Income Growth		High Income Growth	
	Million tons	**Annual Growth (%)**	**Million tons**	**Annual Growth (%)**
Own Base Scenario (1)	1.54	1.06	1.96	2.30
Own Eliminating Tariff	1.40	0.58	1.72	1.63
Own Eliminating Tariff High Pop. growth	1.63	1.31	2.03	2.45
Nieuwoudt	1.63	1.36	2.39	3.31
Briedenhann (2)	1.55	1.10	-	-
Briedenhann Low Pop. Growth (2)	1.33	0.99	-	-

Source: Briedenhann (2000), Nieuwoudt (1998b) and Own Calculations.
Notes: 1. From Table 8. 2. Results for Briedenhann include oilcake + 1.4*fishmeal.

Base scenario forecasts indicate potential for increased protein use as SA nears 2020. Under low (high) income growth, meal consumption increases 15% (30%) by 2010 and 24% (58%) by 2020. If the long-term growth in world protein supply of 3% is maintained, world prices are forecast to decrease 4% by 2020. Linking to the international model in this case leads to projections that are about 1.5% greater than base scenario forecasts. The model estimates that eliminating tariffs constrains consumption projections by 11% to 12%.

Assumptions concerning future population growth are vital in estimating future protein use, especially under a low-income growth scenario. Two population growth scenarios (high and low population growth) show protein usage would be 19% greater or 7% lower than the base scenario. It therefore appears that South African oilcake usage and imports is unlikely to increase dramatically to 2020 as previously considered likely. The impact of HIV/AIDS is evident since the high population growth can be considered an HIV/AIDS free scenario. A worst case HIV/AIDS scenario assumes stable per capita income levels and declining real prices for livestock products, and thus may underestimate the effects of population decimation. Policy that lessens negative HIV/AIDS effects is clearly desirable to the livestock and feed industries.

The poultry industry is the currently the largest South African consumer of protein feed and accounts for a significant share of projected use. The future success of this industry is therefore critical in determining the level of local demand for protein feed. In the absence of tariff protection, access to cheap feed (including imports) is crucial to competitiveness. Since large international protein price increases are not expected over the long-term, efforts to stimulate local protein production should focus on achieving a quality and cost advantages. Policy makers, who risk penalising one industry when protecting another, need to consider relationships along the entire value chain when evaluating changes in protection of industries.

Long-term projections can never be made with certainty. However the value of this research does not lie so much in predicting the future as in clarifying important determinants of meal consumption under different scenarios and structuring this information in an easily operable spreadsheet model. This helps decision-makers to make informed decisions given the expected economic and social conditions.

REFERENCES

ADAM, M.S.A. (1998). *Impact on South African meat demand of a possible free trade agreement with the European Union*. Unpublished MSc Thesis. University of Natal, Pietermaritzburg.

AFMA. (2000). Personal Communication. Animal Feed Manufacturers Association. Rivonia, South Africa.

BRIEDENHANN, E. (2000). *A model to predict the animal feed and raw material requirements for the animal feed industry in South Africa*. Unpublished PhD Thesis. University of Natal, Pietermaritzburg.

BUSE, R.C. (1958). Total Elasticities – A Predictive Device. *Journal of Farm Economics,* 40:881-891.

COETZEE, Z. (2000). Personal Communication. South African Poultry Association. Johannesburg, South Africa.

DELGADO, C., ROSEGRANT, M., STEINFELD, H. & COURBOIS, C. (1999). *Livestock to 2020: The Next Food Revolution*. International Food Policy Research Institute. Food, Agriculture and the Environment Discussion Paper 28, http:/www.cgiar.org/ifpri/2020/welcome.htm.

FERGUSON, N.S. (2001). Personal Communication. Animal and Poultry Science. University of Natal, Pietermaritzburg.

FRIEDMAN, M. (1962). *Price Theory*. Provisional text. Aldine Publishing Company, Chicago.

GOUS, R.M. (2001). Personal Communication. Animal and Poultry Science. University of Natal, Pietermaritzburg.

GRIESSEL, M. (2000). Personal Information. Saldanha Animal Feeds, Johannesburg.

HALL, A.D. (2001). Cotswold International, Rothwell Lincolnshire LN7 6BJ U.K. Personal Communication.

HALL, A.D., NIXEY, C. & WEBB, A.J. (2000). Recent Developments in Animal. Genetics in the Context of Animal Nutritional Strategies. *Recent Advances in Animal Nutrition – 2000*, 11-22.

MARSH, J.M. (1999). Economic factors determining changes in dressed weights of live cattle and hogs. *Journal of Agricultural and Resource Economics*, 24(2):313-326.

MARTINS. (1999). *Household expenditures in South Africa by province, population group and product, 1999*. Bureau of Market Research Report No. 261, University of South Africa, Pretoria.

McCAY, J.C., BARTON, N.F., KOERHUIS, A.N.M. & McADAM, J. (2000). *Broiler production around the world*. XXI World's Poultry Congress Montreal, Canada, August 20–24 2000. Abstracts and Proceedings CD, 6th International Symposium.

NDA. (2000). *Abstract of Agricultural Statistics*. Directorate: Statistical Information of the National Department of Agriculture, Pretoria.

NIEUWOUDT, W.L. (1998a). The Demand for Livestock Products in South Africa for 2000, 2010, and 2020: Part 1. *Agrekon*, 37(2): 30-141.

NIEUWOUDT, W.L. (1998b). The Demand for Protein Feed in South Africa for 2000, 2010, and 2020: Part 2. *Agrekon*, 37(2):142-159.

OIL WORLD. (2000). *Oil World Monthly*. Various Issues. ISTA Mielke GmbH, Langernberg 25, 21077 Hamburg, Germany.

RAE, A.N. & HERTEL, T.W. (2000). Future Developments in Global livestock and grain markets: The impact of livestock productivity convergence in Asia Pacific. *The Australian Journal of Agricultural and Resource Economics*, 44(3):393-422.

SAMIC. (2000). *South African Meat Industry Company*. http://www.samic.co.za/.

SARB. (2000). *South African Reserve Bank*. http://www.resbank.co.za/.

SCHROEDER, T.C., BARKLEY, A.P. & SCHROEDER, K.C. (1995). Income Growth and International Meat Consumption. *Journal of International Food and Agribusiness Marketing*, 3:15-30.

STATSA. (2000). *Statistics South Africa*. http://www.statssa.gov.za/.

TOMEK, G.W. & ROBINSON, L.K. (1990). *Agricultural Product Prices*. Third Edition. Cornell University Press.

US CENSUS. (2000). *U.S. Census Bureau, International Programs Center*. http:www.census.gov/ipc/www/.

VAN AARDT, C.J., VAN TONDER, J.L. & SADIE, J.L. (1999). *A projection of the South African population, 1996-2021*. Bureau of Market Research Report No. 270, University of South Africa, Pretoria.

A. APPENDIX

An index of future demand, assuming constant price, is calculated for poultry, beef, pork, lamb/mutton/goat, eggs and dairy as follows:

$$Index_{py} = 100 * DDF/Con \qquad (9)$$

where

$Index_{py}$ is the future demand of product p in year y.

Con is the total consumption in base year (2000) for product p. Calculated as:

$$Con = BUP*BUC + BRP*BRC + AP*AC + CP*CC + WP*WC \quad (10)$$

BUP, BRP, AP, CP, WP are population numbers for urban blacks, rural blacks, Asians and whites respectively in 1999. BUC, BRC, AC, CC, WC are per capita consumption figures for product p for urban blacks, rural blacks, Asians and whites respectively in 1999.

DDF_p is the projected future demand of product p in year y at constant prices, calculated as:

$$DDF_p = ((1+BUI)^{\wedge n}-1)*BUE+1)) * (1+BUPg)^{\wedge n} * BUC + ((1+BRI)^{\wedge n}-1) * BRE+1)) * (1+BRPg)^{\wedge n} * BRC + ((1+AI)^{\wedge n}-1) * AE+1)) * (1+APg)^{\wedge n} *AC + ((1+CI)^{\wedge n}-1) * CE+1)) * (1+CPg)^{\wedge n} * CC + ((1+WI)^{\wedge n}-1) * WE+1)) * (1+WPg)^{\wedge n} * WC. \quad (11)$$

BUI, BRI, AR, CI, WI are projected per capita income growth rates for urban blacks, rural blacks, Asians and whites respectively. BUE, BRE, AE, CE, WE are income elasticities for urban blacks, rural blacks, Asians and whites respectively. BUPg, BRPg, APg, CPg, WPg are population growth rates for urban blacks, rural blacks, Asians and whites respectively in 1999. The number of years from base year to projected year is represented by "n".

B. APPENDIX

Appendix Table A: Income elasticities by product and population group

	Asian	Urban Black	Rural Black	Coloured	White
Beef	0.65	1.04	1.33	0.7	0.34
Poultry	1.09	0.66	1.33	0.65	0.32
Pork	0.4	0	0.25	0.6	0.32
Mutton/Goat	1.65	1.3	1.52	0.65	0.23
Eggs	0.53	0.74	1.42	0.53	0.15
Milk	0.74	0.5	0.6	1.07	0.21

Appendix Table B: Total price elasticities of demand used in the model

	Beef	Poultry	Pork	Mutton/Goat	Eggs	Milk
Elasticity	-0.82	-0.77	-1.05	-0.82	-0.3	-0.78

Appendix Table C: Conditional Slutsky price elasticity estimates

	Beef	Poultry	Pork	Mutton/Goat
Elasticity	-0.42	-0.32	-0.8	-0.43

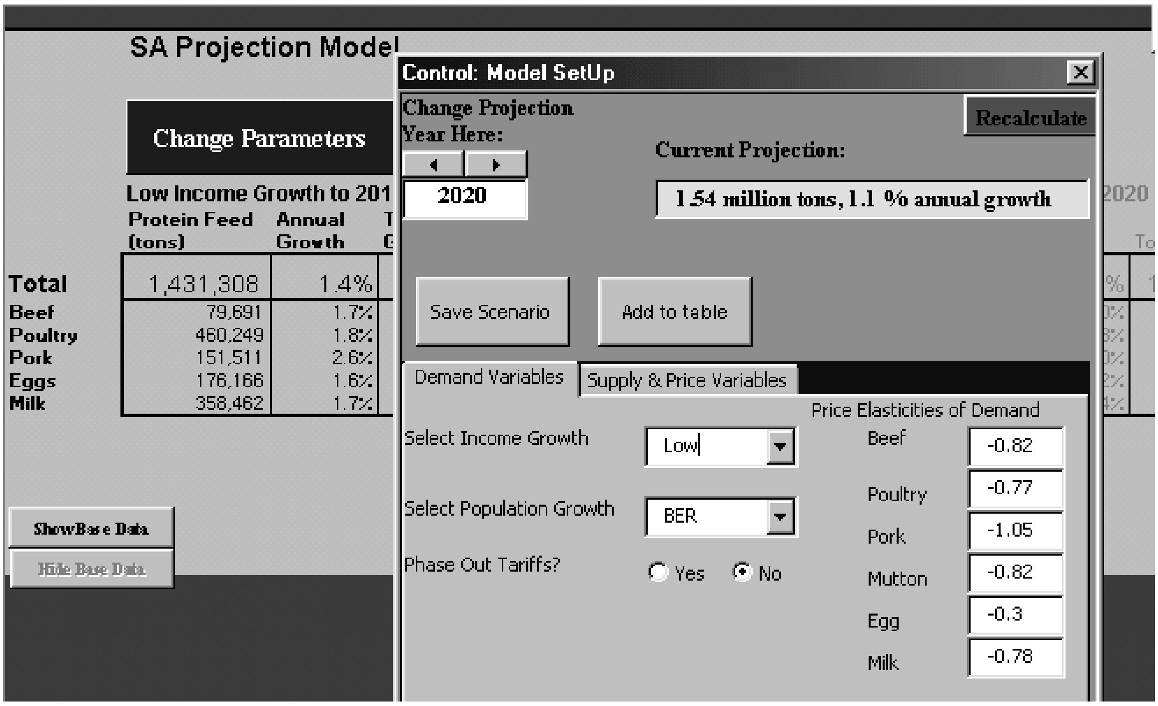
Source: Adam (1998).

Appendix Table D: Protein consumption indices by product (2010 and 2020) assuming constant international price

	Low Income		High Income	
	2010	2020	2010	2020
Beef/Sheep	118	123	157	196
Poultry	119	131	143	186
Pork	129	149	135	163
Eggs	117	126	134	167
Milk	105	108	110	118

Source: Own Calculations.

Figure 3: Spreadsheet Model Control Screen and Model SetUp Form


SA Projection Model
Change Parameters
Low Income Growth to 201
Protein Feed (tons)
Annual Growth
Total 1,431,308 1.4%
Beef 79,691 1.7%
Poultry 460,249 1.8%
Pork 151,511 2.6%
Eggs 176,166 1.6%
Milk 358,462 1.7%
ShowBase Data
Hide Base Data
Control: Model SetUp
Change Projection Year Here:
2020
Recalculate
Current Projection:
1.54 million tons, 1.1 % annual growth
Save Scenario
Add to table
Demand Variables
Supply & Price Variables
Select Income Growth
Low
Select Population Growth
BER
Phase Out Tariffs?
Yes
No
Price Elasticities of Demand
Beef -0.82
Poultry -0.77
Pork -1.05
Mutton -0.82
Egg -0.3
Milk -0.78