Projecting International Demand for and Supply of Protein Feed

By:

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I hereby certify that unless specifically indicated to the contrary, this thesis is the result of my own original work.

Sean McGuigan

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I give all thanks and praise to the Lord Jesus Christ, who blessed me with this opportunity to study and answered all my prayers along the way.

Commit your work to the Lord and your plans will be established...Proverbs 16:3

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Abstract

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 about R1 billion. Internationally, protein prices reached high levels in 1996/97 following increased Asian demand but then fell considerably in response to the Asian financial crisis and increased supply. The South African Protein Research Trust, who invest in research aimed at stimulating the local protein industry, are interested in the most likely long-term trends. Projections of world meal prices and local protein requirements under a variety of scenarios indicate the possible cost of future imports and the potential for local production. These can help strategists to make informed decisions when evaluating plans that impact on future production capacity.

Two interactive spreadsheet models have been developed which estimate protein usage and price under various scenarios and thereby serve as a decision support system. The first model projects future world supply of and demand for oilcake and calculates equilibrium price and consumption using estimated price elasticities of demand and supply. Demand projections are driven by estimated population and income growth while supply is forecast based on past production trends. The model incorporates dynamic income elasticities of demand that decline with rising real incomes. Assuming a 3% annual growth in supply the model forecasts that real price for protein meal will remain relatively constant at 1999 prices to 2020. However, if supply increases linearly price is forecast to increase 22% by 2020. Developing Asia, notably China, accounts for most demand growth and projections are sensitive to income growth assumptions for China.

A second model estimates South African consumption of oilcake to 2020 Novel features of the model include: the price of protein is endogenous as it is generated by the international model; it incorporates estimated rates of technological progress in livestock production, and predicts the resulting real price change and; use is made of declining income elasticities of demand. Population growth projections include the estimated effect of AIDS which could reduce population growth rates by killing adults and children and reducing fertility amongst women who are HIV positive. Total protein consumption in 2020 is projected at 1.54 million tons (a 24% increase from 2000) under low income growth and 1.96 million tons (a 58% increase from 2000) under high income growth. Declining 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.

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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 (AFMA, 2000). Most of this oilcake is soymeal for use in the poultry industry for broiler and breeder rations. The poultry industry is itself under threat from imported products.

Internationally the 1990's witnessed considerable change in the oilcake market. Industrialized nations continue as the largest consumers of meat products and therefore of protein feed, although growth in consumption is low. In developing Asia however oilcake usage increased exponentially, growing annually at 5.6% from 1990 to 2000, a per capita consumption growth rate of over 4%. Initially this sudden increase in world demand was not matched by increases in supply, with the result that meal prices reached high levels in 1996/97. Some market commentators, believing that world food production will struggle to meet increased demand, heralded this as the start of a global food environment characterized by undersupply and high prices.

In actuality, the Asian financial crisis exposed the importance of per capita income in the demand equation and, as economic growth slowed, demand for meal fell. Concurrently, oilseed producers demonstrated their responsiveness to high prices by increasing acreage planted and, aided by favourable weather conditions, harvested a record oilseed crop. The resulting high supplies of oilcake in a depressed market caused prices to drop to record low levels in 1998.

Against this economic background, the Protein Research Trust (PRT) posed the following questions:

- What will be the future world supply of and demand for oilcake over the next 20 years?

- Will limited international supplies of oilcake make imports prohibitively expensive or will an abundance of low priced protein be available?
- What will be the future local requirements of oilcake over the next 20 years?
- Will the consumption growth experienced recently in South Africa continue and what effect will acquired immune deficiency syndrome (AIDS) have on local consumption?
- What factors influence the answers to these questions?

The PRT invests in research aimed at stimulating the local protein feed industry. Providing probable answers to the above questions, and estimating how alternative scenarios change these answers will guide the long-term strategy of the PRT. A decision support system, based on careful projections will enable strategists to make informed decisions when evaluating plans that impact on future production capacity.

In this thesis, two interactive spreadsheet models have been developed as a decision support system that assists in answering the above questions under various scenarios. The models are constructed in Excel 97 using the Visual Basic for Applications development language, such that they can be readily updated and are useful for scenario analysis.

The first model projects future world supply of and demand for oilcake. Protein meal demand is derived from demand for livestock products. Population and real per capita income growth drive demand growth for livestock products and therefore the demand model incorporates these parameters in estimating future demand for protein feed. The model incorporates dynamic income elasticities of demand that decline with rising real incomes. Supply growth is driven largely by technological advances and to a lesser extent by bringing unused land into production. In the absence of detailed information about factors affecting oilcake supply, and the difficulty of developing an accurate model for supply, future supply shifts are projected based on past production trends. Equilibrium price and consumption are calculated using estimated price elasticities of demand and supply.

A second model estimates South African consumption of oilcake to 2000. As in the international model, South African protein meal demand is derived by meat demand, which in turn is driven by population and income growth. Final consumption of meat products is determined by future livestock product prices. Novel features of the model include the following: the price of protein is endogenous as it is generated by the first model; it incorporates estimated rates of technological progress in livestock production, and predicts the resulting real price change and; use is made of dynamic income elasticities of demand.

In chapter 1 the international oilcake market and recent trends in production, consumption and price of oilcake are discussed. Factors affecting supply of and demand for oilcake are explained and the findings of projections made by other organizations are briefly discussed in chapter 2. Chapters 3 and 4 describe the methodological development of the international model and present projection results. Development of and results from the South African model are given in chapter 6. Chapter 7 considers various tariff implications and the source of future oilcake requirements. A discussion of the main findings of both the international and South African models together with implications for decision- and policy-makers concludes the paper.

Chapter 1
The International Market for Protein Meal

1.1 Market Share of Oilcakes

Oilseeds are processed for the joint products oilcake (meal) and vegetable oil. The meal has a high protein content and is therefore a valuable ingredient in feed rations. Oilcake has largely replaced fishmeal as a source of feed protein in South Africa due to limited supply and relatively high prices of fishmeal (Griessel, 1999). Fishmeal production has remained relatively constant over time (0.23% annual growth 1987 to 1997), in contrast to the high growth for soymeal (2.95% 1987 to 1997) and total meal (3.14% 1987 to 1997) (Figure 1-1). Globally fishmeal usage for animal feed is unlikely to increase significantly and consequently the nine major oilseeds (Table 1-1) crushed internationally are considered in this paper.

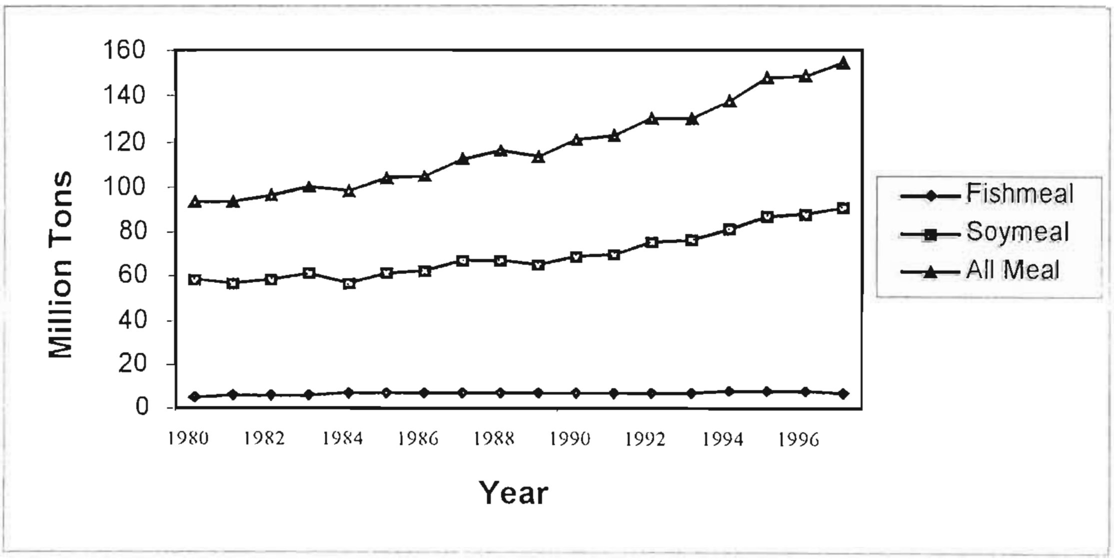

Figure 1-1: World production of Fishmeal, Soymeal and Total Meal 1980 to 1997.
Source: FAO (2000).

Oilseeds yield oil and meal in varied ratios and contain differing percentages of crude protein. Soybeans yield up to 80 percent meal while containing the highest crude protein percentage (Table 1-1) and most complete amino acid content of all oilcakes (Degussa, 1996).

Table 1-1: Oilcake share of world production (2000), trade (1999) and average percentage crude protein of different oilcakes.

	% Crude Protein	% Market Share	% Trade Share
Cake of Coconuts	18.55	1.05	1.07
Cake of Cotton Seed	41.91	7.75	1.09
Cake of Groundnuts	43.20	3.52	0.44
Cake of Linseed	30.00	0.87	0.69
Cake of Palm Kernels	14.23	1.80	5.63
Cake of Rapeseed	35.13	11.87	7.55
Cake of Sesame Seed	41.09	0.51	0.03
Cake of Soya Beans	45.64	61.12	75.73
Cake of Sunflower Seed	33.51	6.81	6.78

Source: Degussa (1996) and FAO (2000)

Soymeal dominates the international protein meal market in terms of both market and trade share (Table 1-1). Figure 1-2 shows production of different oilcakes, emphasizing the dominance of soymeal. In 2000, soymeal consumption exceeded 100 million tons (61 percent of total oilmeal produced) and world soymeal trade exceeded 32 million tons (75 percent of total meal trade). Rapeseed meal is also widely used, although only meal from rape varieties low in glucosinolates (sometimes traded as Canola) is suitable as animal feed. Cottonseed meal, consumed largely in Asia, is the third most consumed oilcake although trade is minimal.

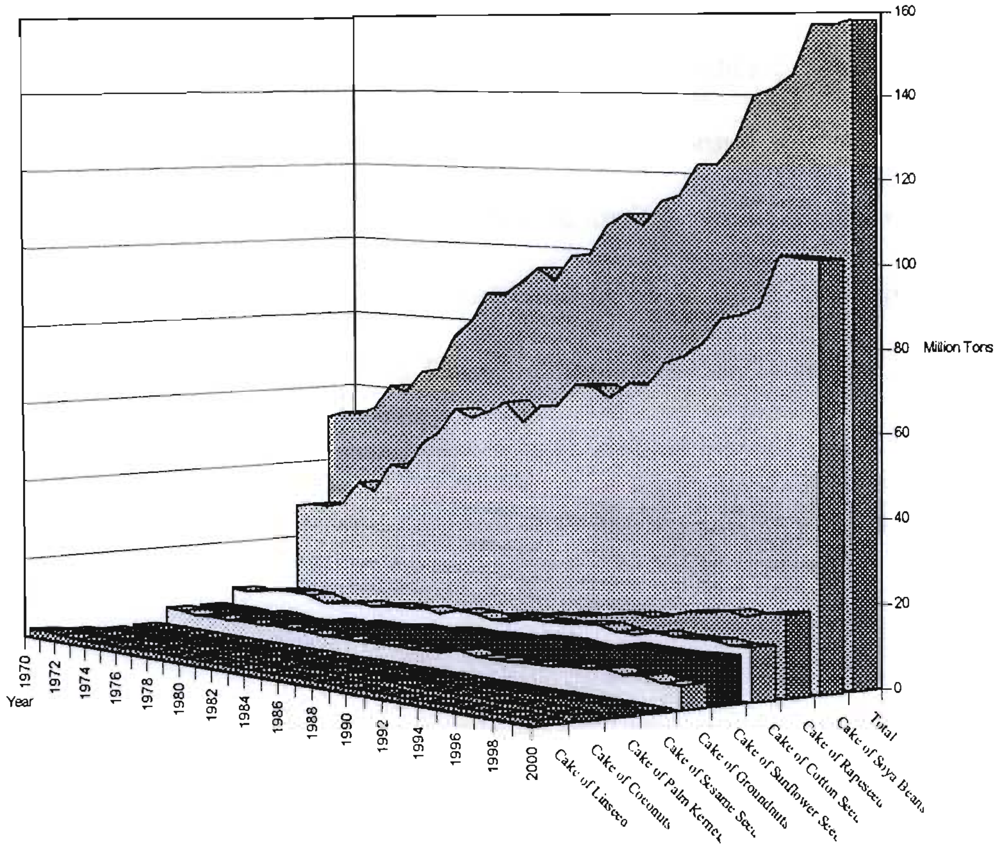

Figure 1-2: Global consumption of major oilseeds (1990 to 2000), million tons.
Source: FAO (2000)

1.2 International Consumption Trends of Oilcake

Presently the high-income countries of the industrial world consume the greatest quantity of protein meal in both per-capita and absolute terms (Table 1-2). For example, the EU (108kg/capita) and the USA (118kg/capita) consume 44 % of world oilcake production. Per capita meal usage in Japan is low because of high meat imports and the large quantity of fish consumed. Per capita consumption of oilcake is significantly lower in the developing countries of Asia (15kg/capita), Africa (8kg/capita) and South America (25kg/capita) than in the industrial world. Total consumption of oilcake in developing Asia however is substantial at 31 % of world supply. China (18 kg/capita) accounts for 44% of Asian consumption at (14% of world consumption) followed by India at 19 % (6% of world consumption).

Meal consumption trends from 1990 to 1999, (Figure 1-2) indicate a decline in consumption growth for the EU and USA over recent years. In contrast, meal consumption growth in developing Asia and China has been high (consumption declined following the Asian financial crisis). This trend has occurred in tandem with the significant increases in Asian meat consumption noted by Delgado et al (1999) and Rutherford (1999). From Table 1-2 it appears that, in general, countries experiencing high per capita income growth rates also increase meal usage at higher rates. China accounts for most of the growth in Asian consumption with increases in meal use of 15 % compound per annum between 1989 and 1997.

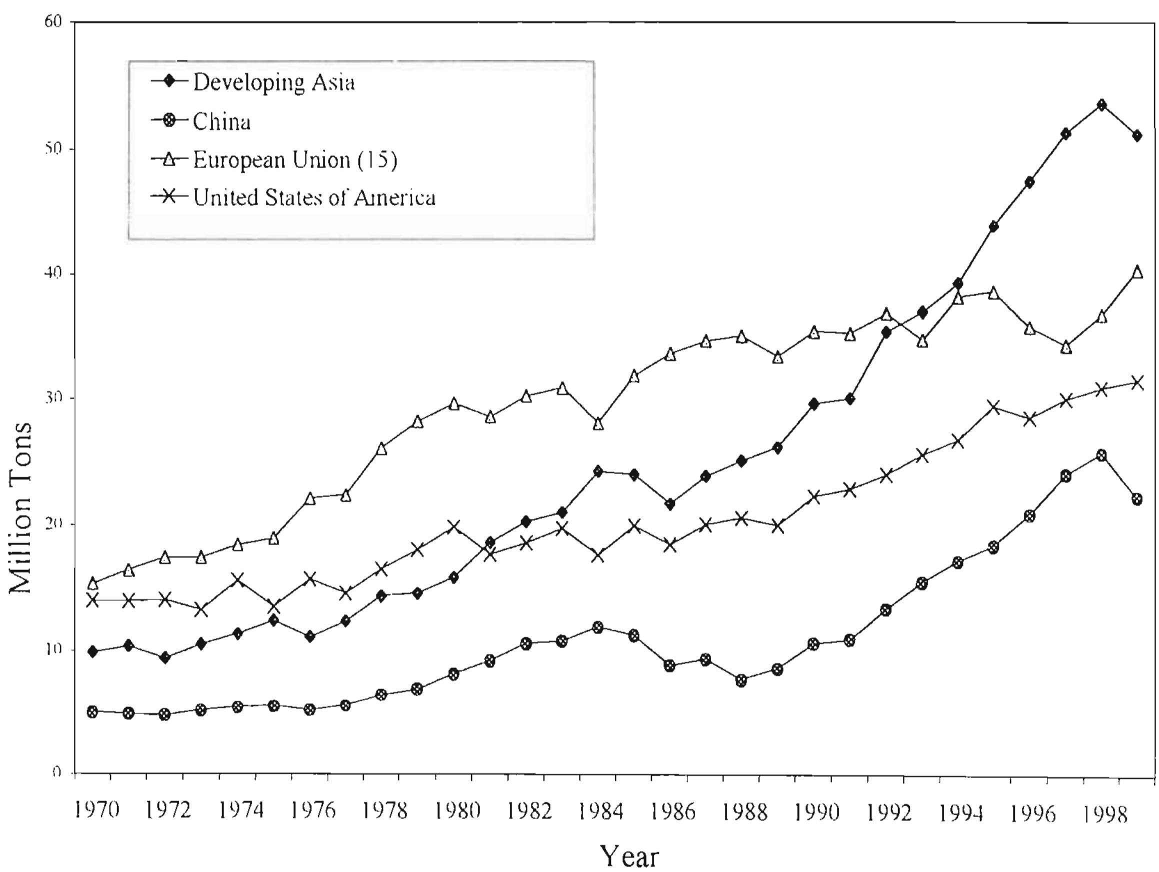

Figure 1-3: Oilcake consumption growth trends (1970-1999)
Source: Own calculations from FAO (2000) data.
Notes: Consumption is production plus imports less exports.

China has an estimated population of about 1.3 billion people or over 20 % of the total world population (World Bank, 1999), and thus accounts for a large share of food production and consumption. Accordingly, changes in Chinese demand have a considerable impact on world markets and international trade (Fan et al, 1994; Rosegrant et al, 1998). The study of consumption patterns in China is therefore important when projecting future world demand (Halbrendt et al, 1994).

Table 1-2: International consumption of oilseed meal in 2000, annual growth in per capita meal usage (1990-2000) and annual GDP growth (1990-1997).

	Total Consumption (Million Tons)	Per Capita Usage (KG/person)	Annual Meal per capita Growth Rate (%)	Annual real GDP per capita Growth rate (%)
World	120.3	13.7	0.20	1.1
				1.6
United States	22.3	117.6	1.03	2.4
Japan	5.3	42.2	-0.12	1.0
EU	35.4	107.5	0.35	*1.8
Developing Asia	29.6	14.9	4.16	NA
China, Mainland	10.6	17.5	6.71	8.9
Indonesia	8.5	11.3	1.27	3.6
Malaysia	0.8	5.1	1.80	2.4
Philippines				5.1
Thailand	0.6	56.1	4.53	4.5
Korea South	2.0	70.6	4.35	2.0
India	0.8	14.9	0.93	0.6
Pakistan	1.1	39.2	7.05	3.3
Latin America	8.2	32.1	5.55	*1.5
Argentina	0.2	18.0	10.81	3.2
Brazil	2.3	41.6	4.40	1.6
Mexico	3.2	44.0	7.34	1.1
Africa	3.6	7.7	2.90	NA
South Africa	0.5	26.3	6.99	-0.6

Source: FAO (2000), IMF (2000) and own calculations.

Notes: 1 Consumption calculated as Production - Exports + Imports. 2 Growth rates are annual compound rates. * Own estimate from available country data.

1.3 International Oilcake Production Trends

Argentina, Brazil and the United States of America (USA) collectively export 70% of world oilseeds and produce about 42 % of world meal and 70 % of world soymeal (Table 1-3). Together with the European Union (EU) (which imports large quantities of oilseed for domestic crushing) these countries account for about 50 % of world oilcake production. Brazil and Argentina are the most important exporters because of their large local production and relatively small domestic consumption.

Oilcake production in Asia was 30 % of world total in 2000, yet Asia is a net importer of protein meal. Only 34 % of Asian oilcake are derived from soybeans compared to 58 % of EU production and upwards of 76 % in Argentina, Brazil and USA. China, the largest Asian producer, manufactures more oilcake than either Argentina or Brazil. China is however a significant importer of oilseeds and oilcake. India, the second largest Asian producer of oilseed and oilcake, is the only Asian exporter of oilcake.

International annual meal production increased about 38% from 1990 to 2000 or at an annual rate of 3.3% (Table 1-3). In the developed world, over the same period, the USA increased production 36% and the EU 23%. Concurrently amongst the major emerging nations, Brazil increased production by 35%, Argentina by 120%, China by 64% and India by 33% (soymeal production increased 100% in India). Argentina has shown the most notable increase in exports following a rise in export market share from 2% in 1980 to 31% in 1999.

Table 1-3: International oilcake production (million tons) and production growth rates 1990 to 2000

Region	Production 1990 (Million Tons)	Production 2000 (Million Tons)	Share of World Production in 2000 (%)	Growth Rate 1990 to 2000 (%)	Annual Compound Growth Rate 1990 to 2000 (%)
World	120.1	166.2	100.0	38	3.3
United States	27.7	37.8	22.8	36	3.2
Japan	4.5	4.4	2.7	-2	-0.2
EU	17.2	21.1	12.7	23	2.1
Developing Asia	33.5	48.5	29.2	45	3.8
China	13.7	22.4	13.5	64	5.0
India	10.9	14.5	8.7	33	2.9
Indonesia	1.2	1.1	0.7	-8	-0.8
Korea South	0.8	1.2	0.7	50	3.8
Malaysia	1.5	2.1	1.3	40	3.6
Pakistan	1.1	1.2	0.7	9	0.8
Philippines	0.8	0.8	0.5	0	-0.2
Thailand	0.5	0.9	0.5	80	6.2
Latin America	23.4	39.3	23.6	68	5.3
Argentina	7.5	16.5	9.9	120	8.3
Mexico	1.9	3.9	2.4	105	7.3
Brazil	12.4	16.7	10.0	35	3.0
Africa	3.2	4.3	2.6	34	2.8
South Africa	0.6	0.6	0.3	0	-0.1

Source: FAO (2000) and Own Calculations

1.4 International Protein Meal Price Trends

While soymeal commands a premium in the oilcake market, annual prices for the most traded meals, soymeal, rapemeal and sunflower meal are highly correlated. To capture the common movement in these prices a principal component analysis (PCA) of monthly prices from 1985 to 2000 was conducted, the results are presented in Table 1-4.

Table 1-4: Principal component matrix of international meal prices 1985 to 2000.

	Component		
	1	2	3
Soymeal	0.950	-0.171	-0.262
Soymeal	0.950	-0.171	-0.262
Sunmeal	0.943	-0.232	0.239
Rapemeal	0.907	0.420	0.026

Component 1 explained 87% of the variation in soymeal, rapemeal and sunmeal monthly prices while the three coefficients of component 1 are of similar magnitude and sign. It can be inferred that meal prices move very closely together because these products are substitutes on the demand side and to a lesser extent on the supply side. A supply or consumption change affecting one meal type affects the others within the same month. Simple correlation of the first component with each price is 0.962 (soymeal), 0.933 (sunflower meal) and 0.901 (rapemeal). Therefore, soymeal price serves as an almost perfect meal price index and is used as an indicator price (Doll and Chin, 1970) for all meal in this study. The reason for the high correlation with soymeal is that it is the dominant feed in terms of value.

Component 2 explains 8.6% of variation occurring when rapemeal prices move in the opposite direction to sunflower meal and soymeal. Doll and Chin, (1970 page 592) note that 'signs of this type may indicate a lagged effect between the series that is independent of the first component'. However, the period considered here is only one month so in the longer term prices are likely to be more closely correlated. Nevertheless, fluctuations orthogonal to main price movement are small. The decision to group all meal types as a single commodity for projection purposes is justified because a projected percentage price increase will be appropriate for the entire meal market.

In the short term there is scope to adjust quantities of different feed types used within the constraints of least cost feed formulations in response to price fluctuations. Substitutions between the different feed types and arbitrage in the market ultimately result in the long-term correlation of prices.

An understanding of price relationships of the major meal types with the less traded meals is also enhanced using the PCA technique. Table 1-5 shows the results of a PCA on annual price data from

1990 to 2000 for 7 meal types[1]. The first component (PC1) accounts for 73.6% of the total variation in the price series while the magnitude of the coefficients is similar (palm kernel meal is the exception) and signs are the same. Again the correlation in price movements for the various meal types is apparent (here groundnut meal is also shown to be a good substitute). The second component (PC2) accounts for 18% of total variation and is primarily correlated with coconut and palm kernel meal. PC2 measures variation in the price series when palm and coconut meals move together. These meals are traded in very small quantities, have low protein content and can be considered by-products rather than joint products since the oilseeds are crushed mostly for oil. When palm and coconut meal are excluded from a PCA the first component accounts for 85% of variation indicating the correlation between prices of the major meals.

Table 1-5: Principal components matrix of international meal prices, 1990 to 2000

	Components	
	1	2
Soymeal	0.872	-0.345
Rapemeal	0.915	-0.273
Sunmeal	0.978	0.177
Groundnutmeal	0.930	-0.302
Cottonmeal	0.780	-0.388
Coconutmeal	0.811	0.582
Palmkernelmeal	0.680	0.720

Internationally real meal prices have declined consistently since the 1970's (Figure 1-4). Nevertheless, prices are sensitive to supply and demand factors as evident in recent fluctuations. Prices in 1996/7 were relatively high (Figure 1-4) following strong increases in global demand, driven largely by high Asian GDP growth, and sluggish growth in world supply. However, by 1998 the Asian financial crisis, caused a decrease in demand while a record world oilseed crop, a result of increased plantings and excellent weather, combined to lead to a market surplus and low prices (USDA, 1999b).

[1] Monthly price data were not available for the less traded meal types.

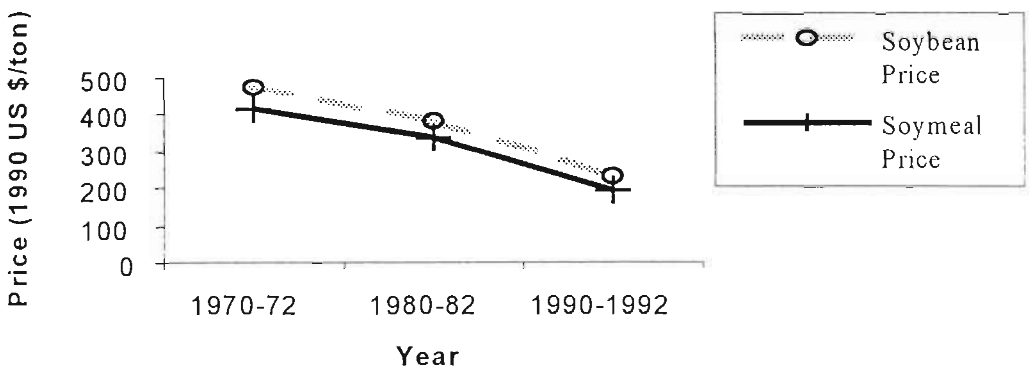

Figure 1-4: Real soybean and soymeal prices from 1970/72 to 1990/92
Source: Delgado et al (1999)

Notes: Soybeans are U.S. c.i.f. Rotterdam, soymeal is any origin, Argentine 45-46% extraction, c.i.f. Rotterdam

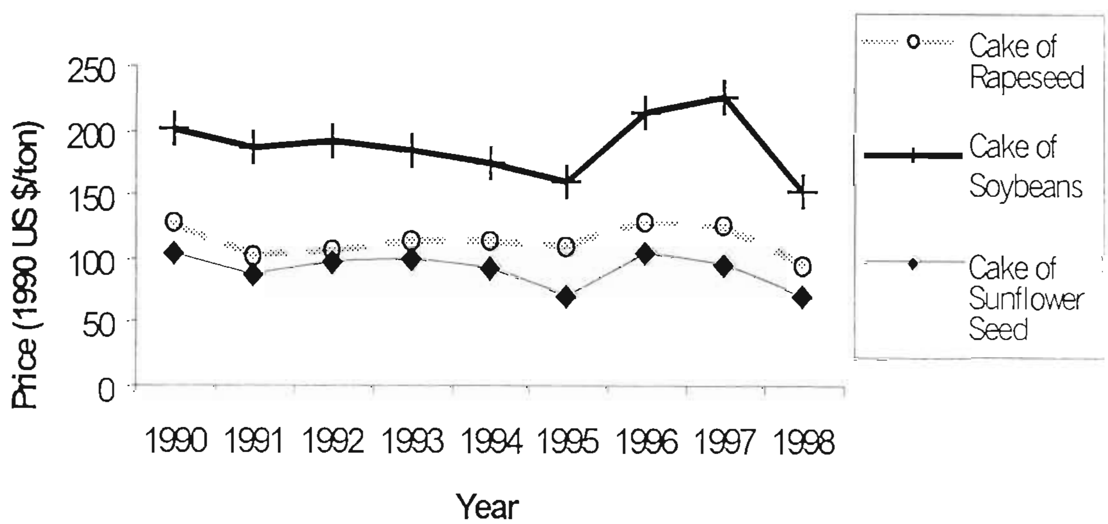

Figure 1-5: Real export prices for selected protein meal from 1990-1998
Source: Own calculations from FAO (1999) data, price calculated as export value ÷ export quantity

Chapter 2

Factors Affecting Future Demand and Supply of Protein Meal

Protein meal is used in the production of animal products and the demand for protein feed is therefore derived from the demand for these products (Deodhar and Sheldon, 1997; Nieuwoudt, 1998b). Feed conversion ratios and livestock inventories also affect the final demand for protein meal[2].

In an individual country, both animal product demand and the extent to which meat products are imported or exported will determine feed demand. Higher meat imports limit local meat production and therefore local feed demand, while a strong export market for livestock products boosts feed demand. For example, high per capita meat consumption and exports support the high level of per capita meal consumption in the USA. The Organisation for Economic Cooperation and Development (OECD) (1998) estimate USA meat exports contain the equivalent of 2 million tons of soymeal. In contrast, reduced competitiveness in the Japanese livestock sector, resulting in higher meat imports, explains the low per capita protein feed demand in Japan relative to other industrial nations in the 1990's (USDA, 1999a).

Global demand for protein feed however, will be largely the same regardless of whether domestic livestock demand is satisfied by locally produced or imported livestock products (OECD, 1998). Economic theory identifies (a) income, (b) population size and distribution, (c) prices and availability of other goods and (d) consumer tastes as the four major factors influencing the level of demand (Tomek and Robinson, 1990). Gilbert (1998), secretary of the International Feed Industry Federation,

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[2] The assumption here is that a linear relationship exists between increases in meat production and corresponding increase in feed usage.

states that world population together with Gross Domestic Product (GDP) do more to direct the feed industry than any other factor, a view supported by both Rosegrant et al (1998) and USDA (1997).

2.1 Income Effect

Per capita income is regarded as the principal determinant of per capita meat demand (Fan et al, 1994; Rae, 1998) and there is a strong correspondence between national per capita income and the long-term demand for meat (USDA 1997). This relationship, shown for the period 1990/91 to 2000/1 in Figure 2-1, appears to hold loosely in the short term. The large deviation observable in 1994/5 corresponds to a period of low meal prices, thus the increased consumption is more likely a result of a price induced movement along the demand curve, rather than an income induced demand shift.

High-income countries such as the USA and member states of the EU display high per capita demand for animal products (see Appendix C, Table C-1) and, therefore, for protein feed. In poorer countries, the level of demand for meat products is lower as is per capita consumption of protein feed. In 1997, per capita oilcake consumption was below the world average (20kg) in the poorer Asian countries namely, China, India, Indonesia, Philippines, and Pakistan. A conclusion by the USDA (1997, 1999a) and Rosegrant et al (1998) is that income is the major determinant in the derived demand for feed. Figure 3-1, showing the relationship between changes in world GDP growth and changes in protein neal demand, supports the conclusion that GDP growth is a significant determinant of meal demand.

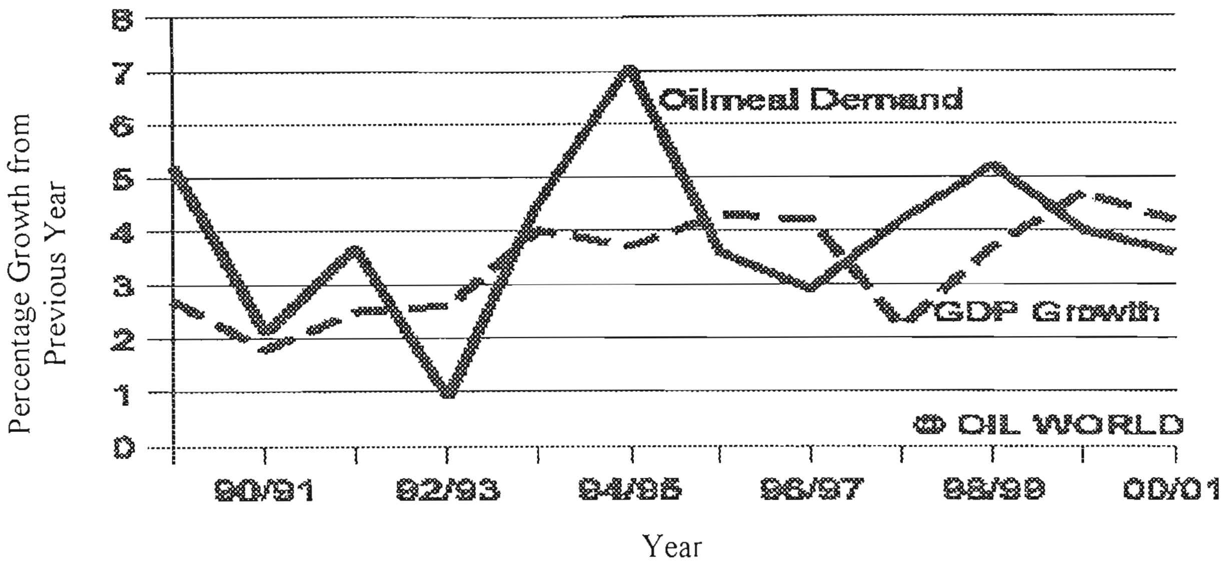

Figure 2-1: Percentage growth in world oilmeal demand vs. percentage growth in world GDP
Source: Oilworld (2000).

Note: Oilworld estimates demand as international consumption of meal.

The Economic Research Service (ERS) of the United States Department of Agriculture (USDA) (USDA, 1997) identify different stages in a country's development in food demand as determined by income level. They observe that moderate-income countries ($500-$1000 per capita income) generally exhibit a transition away from dependence on staples and an increase in the demand for meat and, thus, animal feed. Affluent countries (per capita income greater than $10000) spend proportionally less income on food and the growth in demand for animal products is also lower. This observation is confirmed by recent consumption trends in that poorer but fast growing economies exhibit high growth in meal utilisation (China, South East Asia) while rich countries with slower economic expansion show slow rates of consumption increase.

The Asian financial crisis and subsequent fall in regional GDP growth rates in 1997 and 1998 had a significant effect on livestock and feed consumption. Table 2-1 indicates the extent of the crisis on GDP growth forecasts. GDP growth rates for the East Asian economies, (excluding China) fell from an average of 6.6 percent in 1996 to 4 percent in 1997 and growth is estimated at 0.7 percent for 1998.

China has been less affected by the regional crisis although GDP growth slowed to an estimated 5.7% in 1998. Prior to the Asian financial crisis Malaysia, Thailand, Indonesia and the Philippines were amongst the world's fastest growing import markets for soybeans and meal (USDA, 1999a). Table 2-2 gives evidence of the importance of GDP growth to demand for oilcake. Import growth slowed considerably in most countries over 1997 and 1998 and in many cases growth was negative. Asian economies however recovered over the next 2 years and GDP growth returned to near pre-crisis levels as predicted by World Bank (1998), OECD (1998) and USDA (1999a).

Table 2-1: Effect of Asian Financial Crisis on Estimated and Forecasted GDP growth rates 1996 to 2000.

	Estimate			Forecast	
Region	1996	1997	1998	1999	2000
East Asia & Pacific	8.6	7.8	5.7	6.3	6.7
East Asia & Pacific excluding China	6.6	4.0	0.7	3.1	4.3
South Asia	6.5	5.6	5.8	6.1	6.3

Source: World Bank (1998)

Table 2-2: Developing Asia oilcake imports from 1995 to 1998.

Region	1995 (million tons)	1996 (million tons)	% Growth* (1995-1996)	1997 (million tons)	% Growth* (1996-1997)	1998 (million tons)	% Growth* (1997-1998)
Developing Asia	7.80	10.1	29	11.81	17	11.94	1
China	0.18	2.00	998	3.76	85	3.98	6
Malaysia	0.11	0.19	75	0.14	-23	0.11	-24
Thailand	1.00	1.16	16	1.81	56	1.15	-3
Indonesia	0.98	1.21	23	1.05	-13	0.75	-28
South Korea	2.13	2.35	10	1.90	-19	1.86	-2
Philippines	0.90	0.44	-51	0.84	89	1.07	28

Source: FAO (1999)

Notes: * Percentage growth from previous year.

2.2 Population

Population growth is an important determinant in total demand for livestock products and thus animal protein feed. Total feed consumption in populous countries with low per capita demand is often substantial. In China for example, oilcake consumption is 48 percent of total USA consumption, yet per capita consumption in China is just 15 percent of per capita consumption in the USA. In order to maintain per capita consumption levels, the growth in total consumption must match the population growth.

The rate of urbanisation also has a significant influence on the level of demand and, in general, a positive relationship exists between demand for livestock products and the rate of urbanisation (Rae, 1998). This is particularly important in Asian countries such as Indonesia, China the Philippines, Thailand and Malaysia where large numbers of people still live in rural areas and the rate of urbanisation is high. Increasing per capita incomes usually associated with urbanization are not the only reason for increased meat demand. Urban consumers have greater choice in food selection (Delgado et al, 1999) and may prefer meat products to the higher calorie grain dominated diets of rural dwellers.

2.3 Substitutes and Consumer Tastes

Soymeal is the most important vegetable protein used in animal feed and can be supplemented and substituted to some extent with other oilmeals. In the past, an important substitute for oilcake was fishmeal and a change in the price of this product may have had an impact on oilcake demand. However fishmeal supply has not increased significantly over the past decade and the price has risen relative to oilcake in recent years (Griessel, 1999). In South Africa, this has resulted in a substantial decrease in fishmeal use and higher oilcake usage, as is the trend internationally. Maize gluten and bone or feather meals are other possible substitutes for oilcake.

Consumer tastes are potentially significant at a national level because countries that prefer those animal products for which protein feed is a major input will consume more feed. For example, poultry and pork production utilises oilcake more intensively than does beef production. Chinese consumption of pork and poultry is high relative to beef consumption and Chinese pork consumption is high relative to other countries (see Appendix C, Table C-1). Trends in the consumption of these products, as influenced by consumer taste, also have an impact on feed demand. In 1998 China imported 1.1 million tons of poultry products (USDA, 1999a). Most of these imports consist of wing tips and feet. In contrast consumers in the USA prefer chicken breasts and "white" poultry meat, creating the possibility for China to increase exports of poultry breasts (Wang et al 1998). If local Chinese production is thereby stimulated the demand for feed will increase. China however, is a net exporter of pork and so trends on the world pork market may affect Chinese feed consumption. In the EU, negative impacts on beef demand are due to the BSE and Foot and Mouth crises, health conscious consumers and environmental concerns surrounding intensive beef production. The result could be a long-run substitution of poultry for beef, thereby increasing demand for protein feed (USDA, 1997).

2.4 Income Elasticity

When income elasticity is known, predictions can be made of the effects of an income shift on demand. In developing countries experiencing rapid economic growth, especially those in Asia, the income elasticity of demand for animal products tends to be high (greater than or close to 1) (Rae, 1992). Therefore, increases in income have a significant effect on demand. In affluent nations, the income elasticity of demand for animal products tends to be lower. As income increases, consumers spend proportionately less income on food and, in general, the income elasticity for livestock products will decrease (Tomek and Robinson, 1990).

Over the past decade, developing Asian countries (particularly China) have experienced high per capita income growth rates. Per capita income levels are still low in these countries and therefore economic theory predicts a high-income elasticity of demand for livestock products. As the feed conversion rate for protein feed is fixed in intensive livestock feeding, the income elasticity of protein feed was assumed equal to the income elasticity of animal products in this study.

Factors Affecting Supply

Supply growth of protein meal will be determined by factors that influence both growth in oilseed production at the farm level and by those factors influencing the processing of oilseeds at the industry level. Sections 2.5 to 2.8 examine the major factors that affect supply.

2.5 Technology

The major long term structural determinant of supply is the development of technology that improves yield and efficiency (Tomek and Robinson, 1990). For oilseeds, this involves improving yield through improved seed, genetic modification, fertiliser, irrigation, improved weed control, etc. Genetic engineering in particular is expected to play a large role in shifting the supply curve to the right (Gilbert, 1998) and is discussed in section 2.9. The crushing of seed can be improved by increasing the efficiency of oil extraction and therefore, the yield of oilcake.

Technology is dependent on research and investment provided by industry and government. The industrial world, with greater access to capital, is therefore in a better position to improve yields through innovative technology. Nevertheless, in the developing world there is potential for improving yield by employing available technology. In India for example, soybean yields are less than half the world average, creating the possibility for significant yield improvement.

2.6 Competing Products

A significant determinant of supply is the relative profitability of crops that compete for the same resources. Maize and soybeans are alternative crops in many areas (Tomek and Robinson, 1990) so an increase in soybean prices may lead to an expansion in soybean acreage. In developing countries with rising incomes, demand is expected to shift from grains to meat, stimulating protein feed usage. In response to this changing consumer demand, more land could be transferred from cereal to oilseed cultivation.

2.7 Joint Products

Oilcake and edible oil are joint products and therefore the situation on the world vegetable oil market is important. Since the 1980's growth in demand for oil has outpaced feed protein demand and supply of oil from conventionally crushed oilseeds (USDA, 1997), hence, the increased crushing of high oil-yielding oilseeds, especially palm kernels. The by-product of oil production is oilcake and therefore high oil demand can lead to a greater supply and cheaper prices of oilcake. In the case of palm kernels the impact on the oilcake market is reduced because the palm kernel is the lowest meal yielding oilseed and has a low protein content (OECD, 1998).

2.8 Price and Yield Risk

Price or yield risks affect the position of the supply curve (Tomek and Robinson, 1990). Reduced risk of price decreases as perceived by oilseed farmers should encourage new investment (including increasing planted area) and production of oilseeds. Certain technologies that reduce risk can also shift the supply curve outward.

2.9 Future Impact of Biotechnology Development on Protein Feed Production

Recent progress in genetic engineering (GE) has enabled researchers to alter and move genetic material in living cells, creating genetically modified organisms (GMO's). Using this technique, desirable genetic traits from other species can be artificially incorporated in crops. This has led to the development of soybeans resistant to glyphosate, the active compound in the weed killing herbicide Roundup®. These GMO soybeans, marketed as Roundup-Ready®, enable farmers to kill weeds without also harming the crop. Acreage of GMO soybeans in the USA has increased from 17% in 1997 to 57% in 1999 (USDA, 1999c). The USDA (1999c) found that total herbicide use decreased while yield and profitability increased with the use of GMO soybeans. Such findings indicate that GMO technology could increase future supply growth if widely adopted by producers.

It is envisaged that future development in GE will involve enhancing the value of crops (output traits) (USDA, 1999c). Soybeans with improved oils or amino acid (particularly lysine and methionine) content are already near commercial production (USDA, 1999c). From this technology based perspective the rise in relative importance of rapeseed meal (production increased 6.3% annually from 1980 to 2000 versus 2.82% for soymeal) following the development of double low (low erucic acid, low glucosinolates) rape varieties is interesting. Reducing erucic acid content allowed the oil to be used in human consumption while reducing glucosinolates made meal acceptable as feed, thus making the crop more marketable (Weiss, 1983). Most oilseed GE research is undertaken on rape and soybeans so meal usage from these crops could continue to grow relative to other oilseed meals. An in-depth look at the possible effects of GE on supply, price (especially prices that reflect GE enhanced quality attributes) and marketing are beyond the scope of this paper. However, a shift in future supply is possible and the rate of oilmeal (especially soymeal) supply growth may exceed the rate of supply growth experienced in recent years. Hence, the necessity of developing a model which can allow for different supply growth scenarios.

Although GMO crops promise improved yield and profitability, trade disputes have arisen such as that between the EU and the USA regarding the labeling of GMO crops and products (Frank, 1999). Increasing barriers to trade, such as labeling requirements, may retard the adoption and development of GMO's in the short term. This situation presents a contrasting influence on supply to that proposed earlier. If constraints are imposed on GMO technology in the long-term, growth in production will be retarded.

2.10 Other Projections

A number of institutions including the International Food Policy Research Institute (IFPRI), Food and Agricultural Policy Research Institute (FAPRI), and the United States Department Agriculture (USDA) make long-term projections concerning supply of and demand for food and agricultural commodities. Selected relevant projections are reviewed in this chapter.

USDA (1999a) provides information on production and consumption for several agricultural commodities including soybeans, soymeal and meat (beef, pork, and poultry) for selected countries until the year 2007. Projections by Rosegrant et al (1998), of IFPRI, relevant to this paper include meat and soybean demand for major regions and for China to 2020. FAPRI publish consumption and price forecasts for many agricultural commodities on the Internet.

The outlook for the coming decade is that present trends will continue, although at a decreasing rate (USDA, 1999a). In Western Europe, population growth is almost static and the standard of living is already high. Thus, growth in feed demand is expected to stagnate in this part of the world (Gilbert, 1998; USDA, 1999a). In the USA current consumption growth should be maintained by an expanding poultry sector and meat export market (USDA, 1999a).

In contrast, the developing world is expected to account for most of the growth in meat and protein feed demand (Rosegrant et al, 1998), as has been the trend in the 1990's. This growth will be driven by expected increases in per capita income, urbanization and the self-sufficiency of most of the developing world on domestic meat production. Delgado et al (2000), of IFPRI, foresee a demand "revolution" in the livestock sector characterized by continued increases in developing-country demand for livestock products and an improved ability of global markets to provide cereal and meat products without extreme price increases. The USDA (1999a) forecast China will continue to account for most of this expansion in meat and feed demand.

Growth in the future use of oilcake meals in aquaculture, especially in Asia where China is the most significant importer, is a possibility. Tacon (1997, pg1) believes that the "aquaculture sector will have to base its feeding regimes upon the use of feed ingredient sources whose global production and availability can keep pace with the increasing" demand. Currently fishmeal is the predominant feed used in commercial fish production however, growth rates in fishmeal production (Fig 1.1-1) mean that aquaculture will have to source alternative feed, such as oilcake, to maintain growth (Tacon, 1997).

According to USDA (1999a), expected per capita income gains in Brazil and Mexico will drive feed demand in this region. In Mexico, per capita consumption of oilcake feed is growing and total population is high (with a growth rate of about two percent per annum). Continued economic growth in Mexico could result in this country becoming a significant consumer of protein feed. Increased income growth in the populous South Asian countries of India and Pakistan could result in demand growth for livestock products.

The important question is whether income growth rates will continue and, if so, whether production and exports will match increased global demand. Although Gilbert (1998) and Eicher (1998) contend world supply will be hard pressed to meet the pressures on demand that such growth is likely to bring, other long term forecasts do not expect major food shortages. Delgado et al (1999) observe that the world has considerable reserve capacity for cereal production, whilst Rosegrant et al (1998) state that there should be no pressure on food supply, and that international trade should satisfy expected regional shortages. Womack (1999, http://www.fapri.missouri.edu/Press_Releases/1999/TechRevAddFood.pdf) summarises the weakness of a "Malthusian" view as follows: " in almost 30 years of long-range price projection we have invariably under-estimated global food supply and over-estimated growth in consumer buying power and demand". He also noted that technology growth in areas such as China, Brazil and Argentina tends to outpace population growth. Consequently, FAPRI has revised projection models to increase technology trend lines and account for increasing growth in production.

Future growth in oilseed supply will involve increased yield (stimulated by technology) and increases in acreage. As land becomes more constrained, yield improvements and therefore technology become more important. The outlook of the OECD (1998) is that by 2003 oilseed cultivation will account for 13 percent of agricultural land. Some of this additional land needed to meet the increased demand for oilseed products (meal and oil) is expected to come from land previously used for cereals (notably in India and China) (OECD, 1998).

In the USA limited potential for increased acreage means that yield improvements, expected at 1 percent annually to 2003 OECD (1998), will account for most production increases. Soybean yields in the USA are already amongst the highest in the world at 2.5 tons per hectare (t/ha). Oilseed supply in the EU will be constrained by land availability and reduced farmer subsidies (USDA, 1999a; OECD, 1998).

China is the largest producer in the developing world and yet, as pointed out by Yao and Liu (1998), has only 7 percent of the world's agricultural land and nearly a quarter of the world's population. Yao and Liu (1998) expect future increases in agricultural production will come from improved technical efficiency and higher yields. Soybean yields in China for example are about 1.7 t/ha compared to the world average of over 2 t/ha. India is expected to increase oilseed acreage, especially that of soybeans (USDA, 1999a), and low yields of under one 1t/ha currently achieved could be vastly improved. Strong global meal demand is expected to encourage oilseed producers to increase land acreage in Brazil and Argentina (USDA, 1999a). In Brazil however, increased domestic feed demand could restrict exports. The consumer base in Argentina is small and production should continue to outpace demand. Argentinean exports are expected by the USDA (1998) to continue to increase.

Real commodity prices have fallen since the 1970's, this trend will persist if supply continues to grow faster than demand. Increasing demand for meat products in the developing world may halt the declining price trend as far as commodities are concerned.

Chapter 3

Methodology for Own International Protein Meal Demand and Supply Projections

Global meal consumption and real price are projected to 2020 using 1999 as the base. Future consumption is estimated by the equilibrium solution of projected supply and demand curves. Projections are made for a base scenario, involving various assumptions on critical parameters, and scenarios in which parameters are adjusted allowing for "what if" and scenario analysis. Per capita income and population growth rates are used to estimate future demand. Real GDP per capita growth was used as a measure of per capita income growth.

3.1 Data

Data on oilcake production and trade were retrieved from the FAO (2000) online statistical databases. The major oilcakes are treated as one commodity because of the high level of substitution possible between different oilcakes and the correlation in price movements observed between different oilcakes (See section 1.4). Consumption is calculated as production minus exports plus imports. No data on stock held were obtained and thus consumption figures used assume stocks remain constant. World production is assumed to match consumption (no surplus) in past years, in line with USDA (1997,1999a) world production and consumption levels for 1995 and 1996 that show relatively little change in stocks.

Population growth rate assumptions are taken from World Bank (1999) published forecasts. GDP growth assumptions are USDA (1999a), FAPRI (1999) or FAPRI (2000) forecasted GDP growth rates converted to per capita growth using World Bank (1999) population growth rates for each country. The USDA (1999a) and FAPRI (1999) forecast GDP growth rates to 2008/9. FAPRI (2000) GDP growth ates are forecast to 2009/10. GDP growth rates given for 2008/9 (or 2009/10) are assumed to remain constant through to 2020. FAPRI (1999,2000) publishes GDP growth rates for each year and includes the estimated impacts of the Asian financial crisis. USDA (1999) forecast growth rates are given for the periods 1997 to 2002 and 2003 –2008/9. The model allows the user to choose which source to use for GDP growth rates. FAPRI (2000) GDP growth rates are used for the base scenario predictions.

3.2 Projecting Oilcake Supply Shifts

In the absence of detailed information about factors affecting oilcake supply, and the difficulty of developing an accurate model for supply, future supply shifts are projected based on past production trends.

Production appears to have followed an approximately linear trend over time. For the base scenario projections, an estimated linear regression of production against time for the period 1990 to 2000 is extrapolated to 2020. The period 1990 to 2000 is chosen to capture recent structural changes in supply. However, as shown in Figure 3.1 and Table 3-1 the annual increase in production (slope of linear regression) increased from 1980-1990 to 1990-2000 and an exponential curve can be used to describe the production trend from 1980 to 2000. One can infer therefore that production grew faster during the latter period, and in a non-linear fashion from 1980 to 2000. An analyst projecting future production growth to 2000 by linearly extrapolating production data for 1980 to 1990 would have underestimated supply growth. However, modeling an exponential model for data 1980 to 1990 also leads to an underestimate of future supply growth. The difficulty in determining what data period and which model to use is clear. Alternative scenarios, using supply models described below are therefore also presented in 4.3.1.

A supply index is calculated for each year from the selected base year (Index = 100) to 2020 as follows:

$$SI_N = (SP_N/BP)*100 \qquad (1)$$

Where:

SI_N = Supply Index in year N

SP_N = Projected Supply in Year N (from Linear or Growth Model)

BP = Production of Protein Meal in Base Year[3].

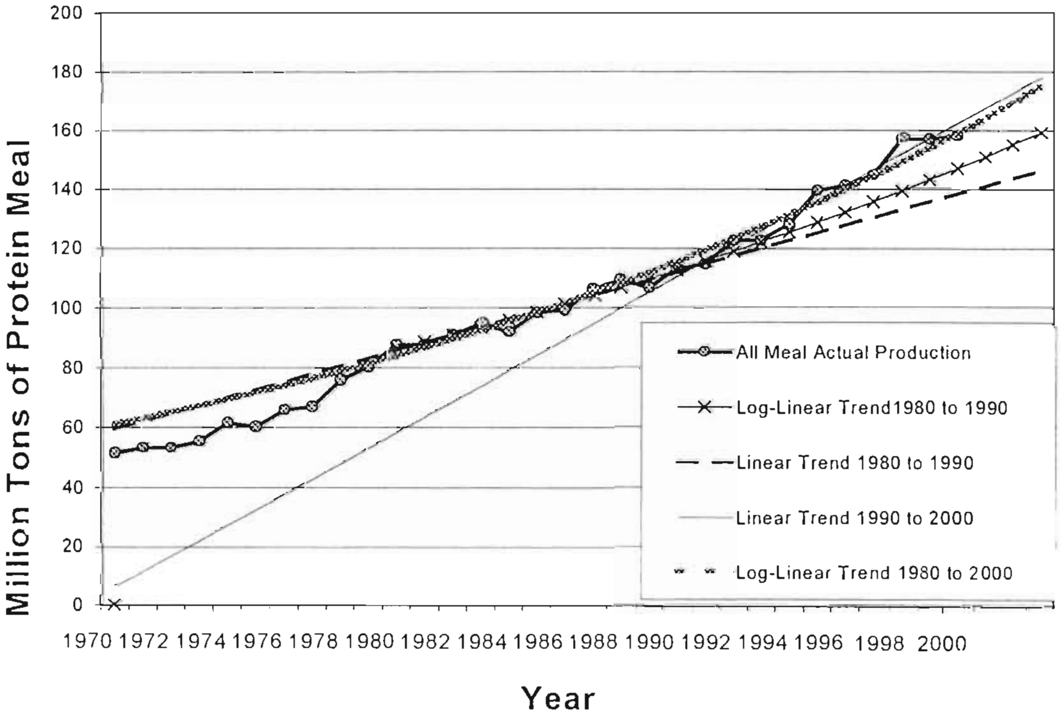

Figure 3-1: Annual world oilcake production from 1970 to 2000 and various supply trend lines. Source: Own calculations from FAO (2000) data.

[3] The model includes the option of calculating BP as an average of production in the Base year and years preceding and following the Base year. This option is useful where record high or low Base year production levels lead to unrealistic supply projections.

Table 3-1: Regression models used to project supply of international protein meal.

	Linear Trend 1970 to 2000	Linear Trend 1990 to 2000	Linear Trend 1980 to 1990	Log-Linear Trend 1970 to 2000
Constant (t value)	-7099.97 (-40.61)	-9925.88 (-16.87)	5080.14 (-11.16)	-58.61 (-28.44)
Year (t value)	3.63 (41.179)	5.04 (17.101)	2.61 (11.373)	0.032 (30.74)
Adjusted R^2	98.3	96.7	92.8	97.9
DW	0.84	2.24	2.51	1.50

The spreadsheet model allows the user to apply either a linear function (y = a+ bx) or growth function (lny = a+ bx) to project future supply at constant prices for time series data for any period between 1970 and 2000. Alternatively, a percentage growth rate can be chosen, based on analyst judgement to project supply. A number of supply growth scenarios can be quickly examined using the interface designed in the international projection model.

3.3 Projecting Oilcake Demand Shifts

As protein meal consumption is derived from the demand for livestock products, projections for meal demand are based on expected income and population growth rates. Demand projections are made for 12 countries and the EU which together account for about 77% of annual world meal consumption. The countries chosen represent the major consumers in the industrial world and those countries identified as having potential for consumption growth in the developing world. All the larger developing Asian and Latin American countries are represented. Projections are made from the chosen base year, to 2010 and 2020. An index for demand in each country after n years is calculated as follows.

$I_i = 100*[\{(1+g_i)^n - 1\}* E_i + 1]*[1+p_i^n]$ (2)

Where:

I_i = Demand Index for country i

g = forecast GDP per capita annual growth rate as a fraction in country i

n = number of years in period

E = income elasticity of demand for meal in country i

p = forecast annual population growth rate as a fraction in country i

The index calculations outlined above are used to calculate future quantity demanded in each country (Index * Base year consumption). A world total demand level (for the selected countries) is obtained by aggregating the projected quantities demanded for each country as detailed below.

$$WI_N = \left[\sum_{i=1}^{13} \frac{(I_i / 100 \; * BC_i)}{WC} \right] * 100 \qquad (3)$$

Where:

WI_N is world index in year N

i = country

I_i is index from (4) above

BC_i is actual consumption in country i in the Base Year

WC is actual world consumption in the Base Year for the selected countries

It is assumed that total world quantity demanded increases at the same rate as that of the selected countries. This assumption is not necessarily valid, as it is likely that the selected countries will consume an increasing share of world production.

3.4 Income Elasticities of Demand for Meal

Estimates of income elasticity are required in order to estimate income-induced demand growth. Income elasticity estimates are not readily available for protein meal demand and thus independent estimates need to be made. Further, income elasticities for individual foods tend to decline as incomes rise (Tomek and Robinson, 1990). It is therefore appropriate to adjust estimated income elasticities over time when making long term projections (USDA, 1997). The use of declining elasticities is especially relevant for China and South East Asian countries, which have experienced high GDP growth rates in recent years.

In the wealthier developed nations, income elasticities are expected to remain relatively constant as incomes are expected to increase more modestly and diets are satisfied. Crompton and Phillips (1993) report income elasticities in the EU for pork and poultry of 0.25 and 0.27 respectively. Own projections use an elasticity of 0.26 for the EU and USA for each year, on the basis that both regions have similar per capita incomes and consumer diets are largely satisfied.

Schroeder, et al (1995) estimated the effects of national per capita income growth on national per capita meat consumption, using annual data for 32 countries for 1975-1990. The authors estimated single-equation demand models for pork, poultry, lamb and beef as follows:

$$\ln Q_{ijt} = \beta_0 + \beta_i \ln P_{ijt} + \sum_h \beta_h \ln P_{hjt} + \beta_{y1} \ln INC_{jt} + \beta_{y2}[\ln INC_{jt}]^2 \quad h \neq I \qquad (4)$$

Where i and h refer to meat commodity (pork, poultry, lamb or beef), j refers to country, t refers to year, Q is per capita consumption, P is price, and INC is per capita income (GDP per capita in U.S. $). GDP per capita are deflated to 1985 constant dollars. The squared INC variable allows income elasticity to vary with income level. The income elasticity is calculated as:

$$\frac{\partial \ln Q_{ijt}}{\partial \ln INC_{jt}} = \beta_{y1} + 2\beta_{y2} \ln INC_{jt} \qquad (5)$$

The parameters βy_1 and βy_2 are shown in Table 3-2 for pork and poultry. Using these parameters and GDP per capita deflated to 1985 constant dollars, income elasticities are estimated for each developing country for poultry and pork to 2020[4]. The income elasticities estimated from (5) for pork are substantiated by other publications and were used as an estimate of protein meal income elasticity of demand in the base scenario forecast for all developing countries except China

Table 3-2: Coefficients of β_1 and β_2 from regression equation 5, as estimated by Schroeder et al.

	β_1	β_2
Pork	3.070	-0.146
Poultry	6.962	-0.367

Source: Schroeder et al (1995)

China's role in the world market is important because of her large population and the fact that China is expected to account for much of protein meal growth in the future. The elasticity used to project future Chinese consumption therefore needs especially careful consideration. Most studies on China's food demand were carried out in the late 80's and early 90's and income elasticity estimates vary widely depending on survey data and model specification (Tian, 1999). Tian and Chudleigh (1999) point out that while earlier studies on income elasticities for livestock products in China obtained high estimates, elasticities might have since declined. The authors argue that parameters estimated in the late 80's and early 90's might be inappropriate for predicting income-induced demand growth into the future. Furthermore, income elasticities estimated by Schroeder et al using equation (5) appear high for China (over 2.0 for poultry and 1.09 for pork) when compared to recent estimates (Table 3-3). For these

[4] The elasticities are restricted from falling below 0.26 (the elasticity used for developed countries).

reasons, the income elasticity for China is estimated as described below, while the elasticity decline as estimated by Schroeder et al (1995) was further incorporated.

Per capita meat consumption in China consists mostly of pork and, to a lesser extent, poultry meat. Beef and lamb are only consumed in very small amounts (USDA, 1997; Crompton and Phillips, 1993). Most oilseed meal is used in pork and poultry production. Table 3 displays income elasticities and population ratios for China.

Table 3-3: Income elasticities of demand and population ratios used to calculate income elasticity of demand for oilcake in China

	Urban	Rural
Pork Income Elasticity	0.50	0.80
Poultry Income Elasticity	0.99	1.10
Percentage Population (1997)	30	70

Source: USDA (1999a), World Bank (1999)

Consumption data for China USDA (1999a) indicates that the ratio of pork to poultry consumed is roughly 75:25. An income elasticity of meal in China for 1997 is calculated as follows from consumption of both pork and poultry.

Urban income elasticity of meat demand = (0.5*0.75)+(0.99*0.25) = 0.623 (6)

Rural income elasticity of meat demand = (0.8*0.75)+(1.1*0.25) = 0.875 (7)

Chinese income elasticity of meat (Pork and Poultry)

= (0.623 * Urban Population Ratio) +(0.875 * Rural Population Ratio)

= (0.623*0.3)+(0.875*0.7)

= 0.80

The income elasticity of 0.80 for China was incorporated in the model along with the information provided by Schroeder et al (1995) on the decline of the income elasticity over time. Because of China's importance in the world market and the fact that urbanisation in China will result in a changing rural to urban population ratio, alternative income elasticities are considered in scenario (what if) analysis.

3.5 Projected International Consumption using Linear Supply and Demand Models

In the above projections of supply and demand, relative prices are assumed constant. Future consumption however depends upon shifts of demand and supply and therefore relative prices of oilcake. The effect of relative prices can be simulated using estimated price elasticities of supply and demand (Nieuwoudt, 1998b).

3.5.1 Estimate of Price Elasticity of Input Demand

Protein feed is an essential factor of production and has no direct substitutes[5]. The price elasticity of input demand for all protein feed is therefore expected to be low. The relationship between the price elasticity of demand for an input (protein feed) and an output (broilers, pork etc) can be described as follows (NCSU, 1975):

$$n_{11} = \alpha_1 n_{yy} - (1-\alpha_1)\tau_{12} \qquad (8)$$

where n_{11} = price elasticity of demand for input (protein feed)

n_{yy} = price elasticity of demand for the product (broilers, pork etc)

α_1 = the factor share of the final product = $\frac{X_1 P_{x1}}{Y_1 P_y}$

where: X_1 = quantity of input (protein feed)

P_{x1} = price of input (protein feed)

Y_1 =quantity of product (broilers, pork etc)

P_y = price of product (broilers, pork etc)

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[5] Protein feed includes all protein meals. Fishmeal is a substitute but use has declined in recent years. To a small extent maize can also be substituted for protein meal but this effect is assumed to be negligible as maize is already included in rations.

τ_{12} = elasticity of substitution between protein and other feeds (It is assumed that for fixed proportions $\tau_{12} = 0$ i.e. cannot replace protein feed.)

The ratio α_1 for broilers and pork is estimated as follows:

For broilers protein required is 20 % of total feed, feed conversion is 2:1, protein content of meal is 0.45 (soymeal). For pork protein required is 18 % of total feed, pork feed conversion is 3:1, protein content of meal is 0.45 (soymeal). Therefore for broilers protein used per 1kg of live mass (0.7 kg dressed mass) = 0.2*2kg/0.45 = 0.89kg. Using a soymeal price of R1500 per ton and broiler price of R8/kg α_1 is calculated as $\frac{X_1 P_{x1}}{Y_1 P_y}$ = 0.24. Similarly for pork (dressed mass 67% of slaughter mass) α_1 = 0.3 using pork price of R9/kg.

Estimates of demand elasticity for meats range between -0.17 to -1.16 for poultry and -0.4 to -0.95 for pork (Delgado et al, 1999; Schroeder et al, 1995; USDA, 1997).

So if n_{yy} = −0.5 for broilers and -0.4 for pork,

α_1 = 1/4 for broilers and 1/3 for pork,

Then estimates of n_{11}= (1/4)(-0.5) = -0.125 and n_{11} = (1/3)(-0.4) = -0.13 are obtained, -0.13 is used for base scenario forecasts. An upper estimate of n_{11} = (1/4)(-1) = -0.25 and lower estimate of n_{11} = (1/4)(-0.2) = -0.05 are derived for use in sensitivity analysis from the ranges of data presented above.

Price elasticities of demand for protein meal as estimated here are lower in magnitude than the estimated income elasticities of demand for most countries. However, the Homogeneity Condition (Slutsky-Schultz relation) is not applicable in this case as protein feed is an input. Little can thus be deduced from the Slutsky-Schultz relation about the relative magnitude of income and price elasticities for protein feed.

3.5.2 Estimate of Protein (Input) Supply Elasticity

Mercier and Myberg (1993) estimate acreage response elasticities for soybeans of 0.176 for the period 1953 to 1989 in the United States. For the shorter periods 1973-1976 and 1986 to 1989 acreage response elasticities of 0.176 and 0.2 respectively were estimated. Price elasticity of supply for international protein meal is taken as 0.19 for base projections in this paper, which is similar to the price elasticity of soybeans, the major source of protein.

3.5.3 Estimating Future Protein Meal Consumption and Price

The demand and supply equations for the Base Year are calculated as follows:

At the Base Year: Quantity Index (Q): = 100

Price Index (P): = 100

Demand:

$$P = 869 - 1/Edd*(P/Q)Q \quad (9)$$
$$P = 869 - 7.7Q$$

Where *Edd* = Price elasticity of demand = -0.13 (base scenario)

Supply:

$$P = -426 + 1/Ess*(P/Q)Q \quad (10)$$
$$P = -426 + 5Q$$

Where *Ess* = Price Elasticity of input supply = 0.2 (base scenario)

Equilibrium indices are calculated at the simultaneous solution of supply and demand equations, where quantity demanded and supplied are from equations 1 and 3. The curves are pivoted on the price axis (intercept kept constant) to maintain supply and demand elasticity constant (see Appendix D.1) at each price i.e. at a price of 100 demand and supply elasticities remain the same as calculated above. The spreadsheet model allows instantaneous adjustment of price elasticities to compare results.

Using this technique implies that the model endogenously determines soymeal price. Certain scenarios will therefore not be accounted for. For example, it is possible that an increase in protein supply, resulting from consecutive good seasons, would lead to depressed meal prices and cause production to increase at a rate slower than that built into the model. Nevertheless, the ease with which this type of model can be updated allows the most recent price and production data to be used. Data should ideally be updated regularly to ensure projections are made from base data that include the latest price and production trends.

Chapter 4

Results and Discussion of International Protein Meal Demand and Supply Projections

4.1 Base Scenario Projections

A summary of the base scenario assumptions is presented in Table 4-1, 1999 as the selected base year. Results for own base scenario projections of international consumption and price are reported in Table 4-2. Projections indicate real price remaining constant and consumption increasing 38% from 1999 to 2010. By 2020, the model projects a real price increase of 22% and a consumption increase of 78% at an annual growth rate of 1.84%. World per capita consumption of meal is projected at 31kg in 2010 and 35kg in 2020 up from 26kg in 1999.

Table 4-1: Base scenario assumptions.

Parameter	Assumption
Per Capita Income Growth	FAPRI (2000) projections
Population Growth	World Bank (1999) projections
Income Elasticities	As calculated in using FAPRI GDP growth rates
Demand Elasticity	-0.13
Supply Elasticity	0.19
Supply Projection	Linear Extrapolation of 1990 to 1999 production data.

The projected price trend to 2010 is relatively flat (Figure 4-1), with prices slightly below base for most of that period. Low, or negative, GDP growth rates following the Asian financial crisis limit annual demand growth, such that supply growth is slightly greater in each year up to 2010. From 2010 to 2020 growth in demand exceeds supply growth, raising projected price. Although the forecast price increase of 22% by 2020 is not considerable, it is of significant importance given the background of consistently falling commodity prices.

Table 4-2: Projected international price and consumption of protein feed to 2010 and 2020

	Quantity (Index)	Price (Index)	Quantity (million tons)	Growth Rates (%) (1)	Quantit (Index	Price (Index)	Quantity (million tons)	Growth Rates (1)
Base Year (1999)	100	100	156		10	100		
	2010				2020			
Base Scenario	138	101	216	2.97	17	122	279	2.78
Sensitivity Analysis								
Demand Elasticity = -0.05	138	100	216	2.97	18	128	282	2.84
Demand Elasticity = -0.25	137	100	216	2.90	17	115	276	2.73
Supply Elasticity = 0.10	138	100	216	2.97	17	129	276	2.73
Supply Elasticity = 0.38	138	100	216	2.97	18	113	282	2.84
Income Elasticity Decreased by 10% in all Countries	136	93	213	2.83	17	109	273	2.67
Income Elasticity Increased by 10% in all Countries	140	107	218	3.11	18	132	285	2.89
Increase Income Elasticity for China by 20% to 0.93 in 1999 (2)	174	109	273	5.16	13	94	213	1.47
Decrease Income Elasticity for China by 20% to 0.62 in 1999 (2)	140	106	218	3.11	18	132	284	2.89
Scenario Analysis								
Supply Scenario1a.(1990-1999) (3)	145	62	227	3.44	19	29	313	3.33
Supply Scenario1b.(1980-1999) (3)	138	97	218	3.00	18	86	293	3.02
Supply Scenario 2. (3.5%) (4)	141	82	221	3.17	19	64	300	3.13
Supply Scenario 3. (3%) (4)	138	99	216	2.97	18	96	289	2.95
Supply Scenario 4. (2,75%) (4)	137	107	214	2.90	18	112	283	2.87
Supply Scenario 5. (10% Greater) (5)	143	71	224	3.32	18	92	290	2.98
Supply Scenario 6. (10% Lower) (5)	132	134	209	2.55	17	155	243	2.57
China Scenarios								
A. Higher Income Growth & Higher Income Elasticity in China (6)	140	109	219	2.55	18	137	287	2.57
B. Lower Income Growth & Lower Income Elasticity in China (6)	136	92	213	2.55	17	107	271	2.57

Notes: (1) Growth in meal consumption compounded annually. (2) In base scenario projections, the income elasticity for China is 0.76. (3) Supply scenarios 1a and 1b use a log-linear regression of production vs. time for the period shown in parenthesis to project supply (growth rate: 1a= 4%, 1b=3.24%). (4) Supply scenarios 2 to 4 assume the supply growth indicated in parenthesis. (5) Supply projections in scenarios 5 and 6 are increased (decreased) by 10% each year. (6) For China scenario A (B) income elasticity is increased (decreased) by 20% and GDP growth increased (decreased) by 5% annually.

Figure 4-1illuminates how supply and demand assumptions affect the projected price. Supply growth is a function of a linear model and therefore annual compound supply growth rates decrease annually as the projected year approaches 2020. Demand growth however is a non-linear function of GDP growth, population growth and income elasticity. Supply growth rates therefore decline relative to demand growth rates, ultimately forcing the model to project increasing prices in the longer term.

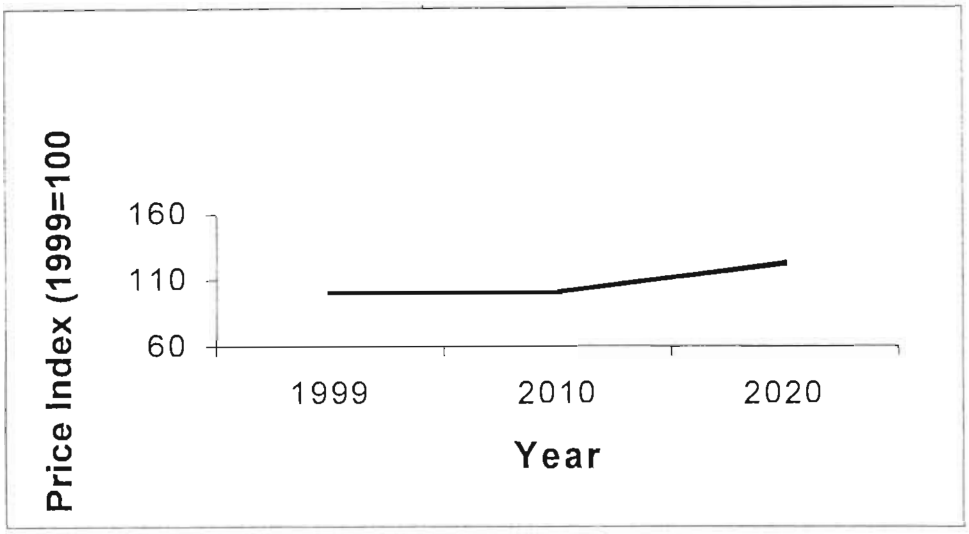

Figure 4-1: Projected international protein meal price trend, 1999 to 2020.

Historically the slope of the production trend appears to have increased at intervals (Figure 3-1), such a shift is possible over the next 20 years. Scenarios using different supply models are considered (see section 4.3) to provide alternative projections.

4.2 Sensitivity Analysis

Adjusting the price elasticity of demand to the upper (-0.25) and lower (-0.05) estimates has a minimal effect on projections to 2010 (Table 4-2). Price projections in 2020 are 4.9% lower for an elasticity of –0.25 and 6.1% greater for an elasticity of –0.05. Similarly, projections do not show large sensitivity to changes in the price elasticity of supply. Increasing the supply elasticity by 100% results in a 6% lower price projection by 2020, while decreasing supply elasticity 100% results in a 7% higher price projection by 2020 (Table 4-2).

The model is substantially more sensitive to changes in the assumed income elasticities of demand. The model is run with all income elasticities increased and decreased by 10% (Table 4-2). Increasing (decreasing) income elasticities leads to price increases of 6.6% (6.7%) and 9.5% (9.7%) by 2010 and 2020 respectively.

Increasing the base year income elasticity for China by 20% results in a price increase of 9.2% (compared to base scenario) and a consumption increase of 2% by 2020. Decreasing China's income elasticity in the base year by 20% decreases price by 9.5% and quantity by 2% compared to base projections.

4.3 Scenario Analysis

Long-term projections are subject to considerable uncertainty and assumptions made about growth parameters have a significant impact on final projections, especially over a 20-year projection horizon. It is therefore prudent to examine the effect of changing the underlying forces driving supply and demand. In this section various scenarios are simulated by altering baseline assumptions of vital parameters, including income growth, supply growth and income elasticity to gain an understanding of how projections might differ from the base scenario.

4.3.1 Alternative Supply Growth Scenarios

Alternative scenarios are run by employing different supply growth projections as described in 3.2. Results for constant supply-growth scenarios and linear projections are given in Table 4-2. Use of a log-linear regression over the period 1990 to 1999 to project supply (growth model) has a dramatic effect on price projections (scenario 1a), with 2020 price forecast at only 29% of base scenario projections. Projected consumption levels are 5% higher in 2010 and 12% higher in 2020. This outcome is expected considering the high supply growth (3.97% for 20 years) of this model. If supply is projected using a log-linear model based on 1980 to 1999 data (scenario 1b), a gentler price trend is projected with prices falling 14% by 2020.

The effect of decreasing supply growth rates is shown in scenarios 2, 3 and 4 (Table 4-2). Growth rates of 3.5% (scenario 2) depress prices, although not as dramatically as in scenario 1. Scenario 3 yields results similar to base projections up to 2010, however by 2020 supply growth is slightly higher than demand growth and price is thus 4% lower. A supply growth rate of 2.75% (scenario 4) is insufficient to match demand growth leading to price increases. The annual compound growth in meal production from 1980 to 2000 was 2.99%, if this long-term growth rate is maintained scenario 3 is most likely. World per capita usage under scenario 3 is forecast at 31Kg in 2010 and 37Kg in 2020, indicating a per capita usage growth rate of 1.7% per annum to 2020.

In the case of the linear model, increasing or decreasing supply by 10% (scenarios 4 and 5) results in relatively large price variation, of up to 28%, although quantity consumed only changes by 4 to 4.5%.

Supply projections made by extrapolating linear and growth models are subject to considerable uncertainty, especially in the distant future. Confidence intervals, calculated at the 95% level of probability for the linear supply model regression (Figure 4-2) were large, showing the statistical measure of uncertainty. In 2020 for example, the base scenario supply projection index is 170 tons; the lower and upper confidence limits for this projection are 127 and 213 respectively. A scenario analysis using supply projections at the upper and lower bounds would force the model to give huge and unlikely variations in projected price. Confidence limits do however indicate the level of uncertainty when making projections for the distant future.

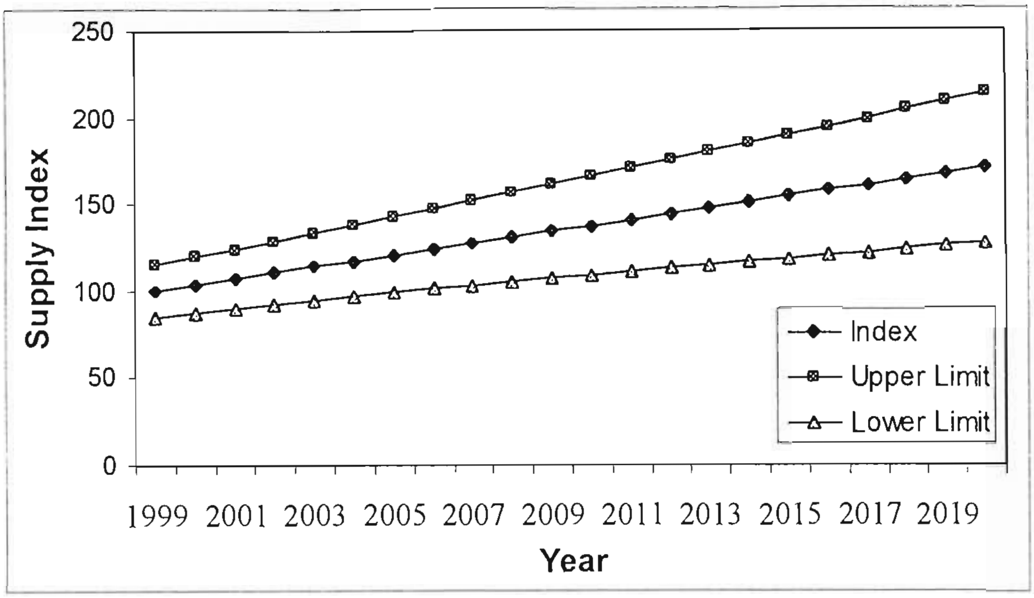

Figure 4-2: Confidence intervals, calculated at the 95% level of probability for the linear meal supply model.

4.3.2 Changing income growth and income elasticities in China simultaneously.

Owing to the importance of China, two more scenarios (A and B in Table 4-2) are presented to demonstrate the simultaneous effects of high (low) income growth in China and higher (lower) income elasticity for China. If different positive and negative effects occur simultaneously, price projections could change significantly. Scenario A shows price increasing 37% by 2020 whereas scenario B shows a 7% increase in price, in comparison to base scenario projections.

4.4 Comparison with other Projections

FAPRI (2000) forecast world soymeal production and consumption to 2009/10 while the USDA (1999a) provide international projections to 2008/9 and USDA (2000) project USA soymeal prices to 2009/10. A shorter-term forecast to 2003 for all meal is made by Knopke et al (1999), with soymeal price used as the indicator price for protein meal. Comparisons are made with own projections for consumption (Table 4-3) and price (Table 4-4).

All studies reviewed project similar consumption to 2003/4 while FAPRI (2000) forecast marginally slower consumption growth to 2009/10. FAPRI (2000) and USDA (1999) project price decreases of 3.4% in real terms by 2009/10, while own projections show meal prices at the same level.

Table 4-3: Comparison international meal consumption projections.

	2003/4 Annual Consumption Growth rate (%)	2003/4 Consumption (million tons)	2009/10 Annual Consumption Growth rate (%)	2009/10 Consumption (million tons)
Knopke et al	2.9	179		
USDA*	3.1	180	2.9	214
FAPRI*	3.1	180	2.6	208
Own Projections	3.1	180	2.9	213

Source: Knopke et al (1999), USDA (1999), FAPRI (1999) and Own Projections.

Notes: * Own estimate of all meal consumed assuming soymeal/all meal ratio of 62%. Consumption growth is annual compound growth from 1999, e.g. assume 4.5yrs to 2003/4. Knopke et al projects growth rates in consumption of 2.9% to 2003, this rate is used to arrive at projections for 2003/4. USDA projects growth rates in consumption of 2.9% to 2008/9, this rate is used to arrive at projections to 2009/10. For Own projections the average of projections for 2009 and 2010 is used.

Table 4-4: Comparison of real (1999 US dollars) international meal price projections

	1999	2003/4	2009/10
		US $ /ton	
Knopke et al	*153	184	
USDA	152	154	165
USDAb			145
FAPRI	152	151	145
World Bank**	#189		244
Own Projections	152	150	152

Source: Knopke et al (1999),USDA (1999), USDA (2000), FAPRI (1999), Oilworld (2000), Delgado et al and Own Projections.

Notes: 1999 base price from Oilworld. *This price was forecast from 1997. ** As presented in Delgado et al (1999), converted to 1999 dollars by inflating with USA GDP deflator. # World Bank projected price for 2000. USDA price projections deflated by USDA projections of inflation (GDP chained price index). FAPRI projections deflated by FAPRI GDP deflator projections, USDAb is USDA(1999) projection to 2008/9, deflated by FAPRI GDP deflator projections, assume price in 2008/9 = 2009/10.

If feed conversion efficiency remains constant, future growth rates for feed and intensively produced meat consumption should be comparable. Demand for protein feed is derived from meat demand and it is useful therefore to compare protein projections to meat projections Delgado et al (1998) make long-term meat consumption projections (Table 4-5) to 2020 using 1993 as a base year. Projected per capita annual growth rates for poultry and pigmeat (from Delgado et al converted to world per capita growth rates) are 1.27% and 0.86% respectively. If it is assumed to that feed efficiency remains constant and that poultry and pig production use all meal in equal amounts the estimated annual growth for protein feed is 1.02%[6]. This is lower than base scenario and scenario 3 projections, which suggest an annual meal per capita growth rate of 1.4% and 1.7% respectively.

However, Table 4-5 indicates that per capita consumption in 1999 was already close to predicted 2020 levels predicted by Delgado et al (1999). Growth rates will have to slow considerably from 1993-1999 levels if projected per capita meat consumption is to be accurate. Apparently, projections made by Delgado underestimate meat consumption growth rates, thereby adding support to the higher growth rates projected in this study.

Table 4-5: Comparison of Delgado Projections with Actual Data.

	1993 kg/capita	1999 kg/capita	1993-1999 annual per capita growth rate (%)	*2020 kg/capita	*1993-2020 annual per capita growth rate (%)
Developed World					
Beef	25	23	-1.2	26	0.2
Pigmeat	28	29	0.5	29	0.2
Poultry Meat	20	24	2.6	25	1.3
Developing World					
Beef	5	6	2.6	7	2.0
Pigmeat	9	11	2.9	13	2.2
Poultry Meat	5	7	4.9	8	2.8
World					
Meat	33	41	3.1	39	#1.0
*Meat***	*29*			*39*	*1.8*

Source: FAO (2000), Delgado (1999)

Notes: * Delgado et al projections. # Delgado et al report 1.8% expected per capita growth. ** Meat consumption reported by Delgado et al differs from FAO.

[6] Pork/(Poultry+Pork) * 0.86% + Poultry/(Poultry+Pork) * 1.27% = 1.02%
where Pork, Poultry are consumption in 1993, ratio of pork to pork plus poultry is 61%

4.5 Performance of Short Term Model Projections.

The model has the capability of making projections from 1997 to the year for which consumption data is available (1999 at present). By selecting historic base years it is possible to compare model projections with actual price and quantity outcomes. Further, by simulating known increases in consumption (by increasing supply) the performance of the model can be tested under situations where supply is correctly projected. For the purpose of these comparisons, soymeal price is used as a representative price for all protein meals. Soymeal prices for 1997 to 2000, against which model projections are compared, are given in Table 4-6.

Table 4-6: Nominal and real international soymeal prices 1997 to 2000

	Nominal Soymeal Price (US $/ton)	Real Soymeal Price (1999 US $/ton)
1997	276	285
1998	170	172
1999	152	152
2000	180	178

Source: Oilworld (2000), FAPRI (2000), and Own Calculations

Model projections from 1997, 1998 and 1999 are compared to actual outcomes as shown in Table 4-7 to Table 4-9. Prices in 1997 were high (see section 1.4) but fell 40% in real terms by 1998, due to high meal supply growth and negative income growth in many Asian countries. The model predicts price decreases under base scenario assumptions because GDP per capita growth rates used are accurate. However, the predicted change is smaller than that actually observed because the model has under-predicted supply growth. In 1998, consumption increased about 8% from 1997 following a record world oilseed harvest. By increasing supply 11%[7] the model simulates an 8% consumption increase and predicted price changes are more accurate.

Table 4-7: Actual vs. predicted meal price changes from 1997 to 2000.

	Actual Price Change	Predicted Price Change	Predicted Price Change*
1998	-40%	-8%	-40%
1999	-47%	-10%	-42%
2000	-38%	-11%	-43%

Source: Own Calculations

Notes: * Simulated supply increase of 11% giving consumption increase of 8% from 1997 to 1998.

Model projections from 1998 to 1999 (Table 4-8) differ substantially. GDP data used in projections show economic recovery and hence growing demand and higher prices are projected. However, in reality prices continued to fall as a consequence of high meal and oilseed stocks and because consumption does not respond instantly to increasing incomes.

Table 4-8: Actual vs. predicted price international meal price changes from 1998 to 2000.

	Actual Price Change	Predicted Price Change
1999	-12%	9%
2000	3%	8%

Source: Own Calculations

Model projections for the period 1999 to 2000 (Table 4-9) show a slight decrease in price as projected supply growth exceeds projected demand increases. In reality prices increased 17% signaling a recovery in the protein meal market. It is interesting to note that this recovery occurred one period after the recovery of economic growth rates, suggesting that demand does not respond instantaneously to increasing incomes.

Table 4-9: Actual vs. predicted price international meal price changes from 1999 to 2000.

	Actual Price Change	Predicted Price Change
2000	17%	-5%

Source: Own Calculations

* In this case an 8% consumption increase is simulated by shifting supply. The projected price at this level of consumption is then observed.

The spreadsheet model is designed to make long term projections, these projections are based on demand and supply growth rates which in turn depend on various assumptions. The model cannot describe market behaviour that results from supply and demand side shocks, as is evident from comparisons given above. The model is more appropriately used to forecast long-term trends, for which it was designed. In the absence of economic shocks and reasonably accurate parameter assumptions, price trends should be correctly predicted.

Chapter 5
Production and Consumption of Protein Meal in South Africa

In 1998/1999 South Africa consumed over 1 million tons of oilcake. A significant proportion of this consumption (54%) is imported. Locally produced soybeans are often processed for full-fat oilcake (70 000 t of the 147 720 t total crop in 1999/00), i.e. the oil content is not removed and the feed thus has a higher energy content. This factor is significant for two reasons. Firstly, maize commonly contributes to the energy content in feed rations and a greater degree of substitutability exists between full-fat oilcake and maize. A low maize price would thus be expected to depress full-fat oilcake prices more than soymeal prices. Secondly, local processors are unable to earn revenues from the edible-oil[8] portion of the soybean, unlike foreign producers to whom the oil is of vital importance. The reason for this situation is that sunflower oil dominates the local edible oil industry. Local oil expressers are better equipped to process sunflower seed and local consumers habitually purchase sunflower oil. However the point has been made that full-fat oilcake provides a more reliable and consistent source of energy and protein (Brookes, 2000) in diets requiring a high energy content, and is thus valued in the feed industry. A disadvantage of full-fat oilcake is that it cannot be stored for long periods.

Soymeal and full-fat soy oilcake dominate the local market with 54% market share although only 26% of soymeal consumed is produced locally. Soymeal accounted for 74% of all oilcake imports in 1998/99. Sunflower meal is the next most important South

[8] Edible oil prices have been relatively low in recent times and crushing margins have often been unprofitable, thus reducing the incentive to crush for oil. In the long-term this may result in decreased investment in plant thereby limiting future oil crushing capacity (Brookes, 2000)

African oilcake with 29% market share in 1998/1999. Most sunflower meal consumed (88% in 1998/1999, 100% in 1999/2000) is produced locally. However sunflower meal has a lower crude protein content than soymeal, rapemeal and groundnut meal and has a poor distribution of amino acids. It is also of limited use in poultry rations where sunflower meal content will not exceed 10% of the ration.

Annual per capita oilcake consumption growth has been high, 6% from 1989 to 1997, and total consumption of oilcake increased 38% (0.3 million tons) from 1995/96 to 1998/99. However, fishmeal consumption decreased by 62% (0.16 million tons) over the same period, indicating that much of the recent increase in oilcake consumption is due to substitution for fishmeal. Imports of meal increased by 211% from 1990 to 1998/99, yet production increased only 14% over the same period. It is clear that South Africa's growing demand for oilcake has resulted in an increased dependence on imports. Production growth in South African oilcake (1.5% per annum from 1990 to 1999) is substantially below international levels (3.6% per annum from 1990 to 1999).

The biggest consumer of protein meal in South Africa is the poultry industry. Nieuwoudt (1998) derives future South African meal usage from projected meat consumption, and poultry consumption is forecast to increase greater than any other meat. Meal use for poultry production (broilers and layers) was projected to rise considerably (Table 5-1), by 2020 projections indicate the poultry industry will consume about 60% of all oilcake (Chapter 6 presents updated projections and scenarios for SA). Recent local trends of increased dependence on imported meal and projected increases in South African protein meal supply highlight the concern of the PRT.

Table 5-1: South African imports and production of fishmeal and oilcake ('000 metric tons) from 1990/91 to 1999/2000.

	1990/1991	1995/96	1998/99	1999/00
Fishmeal Production	na	70	65	80
Fishmeal Imports	na	183	31	15
Oilcake Production	431	474	494	555
Sunflower Meal	271	225	280	365
Soy (Full-Fat & Meal)	84	166	150	129
Cottonseed (Full-Fat & Meal)	na	na	na	29.6
Canola (Full-Fat & Meal)	na	na	na	12.6
Lupins	na	na	na	13
Oilcake Imports	189	300	587	508
Sunflower Meal	3	80	37	0
Soymeal	115	101	435	300
Total Available	620	774	1081	1063

Source AFMA (1999,2000) and FAO (1999)

Table 5-2: Projected consumption of oilcake ('000 tons) in to 2020/1 for high and low income growth from Nieuwoudt (1998b)

	1995/1996 (Actual)	2010/2011 (Low)	2010/2011 (High)	2020/2021 (Low)	2020/2021 (High)
Broilers	231	321	434	388	644
Layers	122	178	213	218	311
Dairy	128	155	188	176	244
Pigs	64	89	96	107	120
Dogs	12	15	15	18	18
Beef and Sheep	39	39	52	39	61
Horses	7	9	9	11	11
Other	49	64	64	75	75
Total	653	872	1072	1032	1485

Source: Nieuwoudt (1998b)

5.1 Projecting Consumption of Protein Feed in South Africa by 2020

Recent increases of oilcake imports have prompted the PRT to request that the international protein market and its impact on the South African (SA) market be studied. Obtaining estimates of future South African consumption, under alternative assumptions of expected future economic and social conditions, gives an indication of the possible future cost of imports and the possible scope for local production. This information will guide decisions affecting future production capacity.

The remainder of this chapter explains the development of an interactive spreadsheet model capable of projecting South African protein feed requirements to 2020. Earlier estimates of future oilcake requirements by Nieuwoudt (1998a,b) suggested significant increases in local usage to 2020. The uncertainty surrounding projections make a dynamic model useful since the impact of changes in vital decision variables (such as AIDS affected population growth and real income growth) on future SA consumption can be readily determined. The capability of a model to offer "what if" analysis and readily provide results for different scenarios is valuable to decision-makers.

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.

First the 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 (Chapter 6) are given for various scenarios. All references to income growth and price are in real terms.

5.2 Background to South African Projections

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 5-3). 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%[9], 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.

Table 5-3: A comparison of actual protein consumption with predictions by Nieuwoudt for the year 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)[10] 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), the new spreadsheet model therefore 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 consumption. Population growth is thus an important determinant of future demand and demographic assumptions, including the possible effects of AIDS, play an important role in future projections. Two alternative population scenarios are considered in section 6.1.

5.3 Consumption Projections for Livestock Products in South Africa

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

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[9] Per capita growth calculated using population growth rates from STATSA(2000)
[10] Price data from SAMIC (2000).

maize and 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.

5.3.1 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[11] are permitted to decline as incomes increase. The demand function estimated by Schroeder, et al (1995) that allows income elasticities to vary with income level is adapted for this purpose (see 3.4, equation 4). Table 5-4 shows how income elasticities 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 5-5.

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

Table 5-4: Income elasticities of demand for poultry by population group in 2000 and 2020, 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 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 5-5 differ by population group and thus consideration is taken of differing social and demographic structures. Following Nieuwoudt (1998a), rural black population is assumed to remain constant.

Table 5-5: Annual South African population and real income growth rate (%) projections (2000 to 2020) 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).

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

$$Index_{py} = 100*(DDF/Con) \qquad (11)$$

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:

$$Con = BUP*BUC + BRP*BRC + AP*AC + CP*CC + WP*WC \qquad (12)$$

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

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

$$DDF_p = ((1+BUI)^{\wedge n}-1)*BUE+1)) * (1+BUPg)^{\wedge n} * BUC + ((1+BRI)^{\wedge n}-1) * BRE+1)) * (1+BRPg)^{\wedge n} * BRC + ((1+AI)^{\wedge n}-1) * AE+1)) * (1+APg)^{\wedge n} *AC + ((1+CI)^{\wedge n}-1) * CE+1)) * (1+CPg)^{\wedge n} * CC + ((1+WI)^{\wedge n}-1) * WE+1)) * (1+WPg)^{\wedge n} * WC. \qquad (13)$$

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, coloureds and whites respectively. BUPg, BRPg, APg, CPg, WPg are population growth rates for urban blacks, rural blacks, Asians, coloureds and whites respectively in 1999. The number of years from base year to projected year is represented by "n".

Table 5-6 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.

Table 5-6: Projected demand indices by product for 2010 and 2020, South Africa, Index is 100 in 2000.

	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 5-5.

5.3.2 Expected Future Demand, Supply and Prices of Livestock Products in South Africa

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.

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)[12]. Consumption is determined by using estimates of demand elasticities 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) 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 absolute terms than the corresponding unconditional estimates, since total expenditure on the group (meat products) is held constant[13] (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, pg. 55).

$$n_{XP} = -Kn_{XI} + \tilde{n}_{XP} \tag{14}$$

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

[12] Expansion of the industry will have no effect on resource prices and therefore on production costs because there are no specialized factors of production, i.e. resources can be increased in the long-term.
[13] Conditional elasticities therefore reflect inter-group competition only, therby reducing the potential number of substitutes

$\tilde{n}_{XP}$ = 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. The estimated total price elasticities of demand are shown in Table 5-7. Alternative upper and lower bound price elasticities are considered in section 6.1.4.

Table 5-7: 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

5.3.2.1 Poultry, Pork and Dairy

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 5-1, the supply function of these factory type products (broiler, egg, and 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 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.

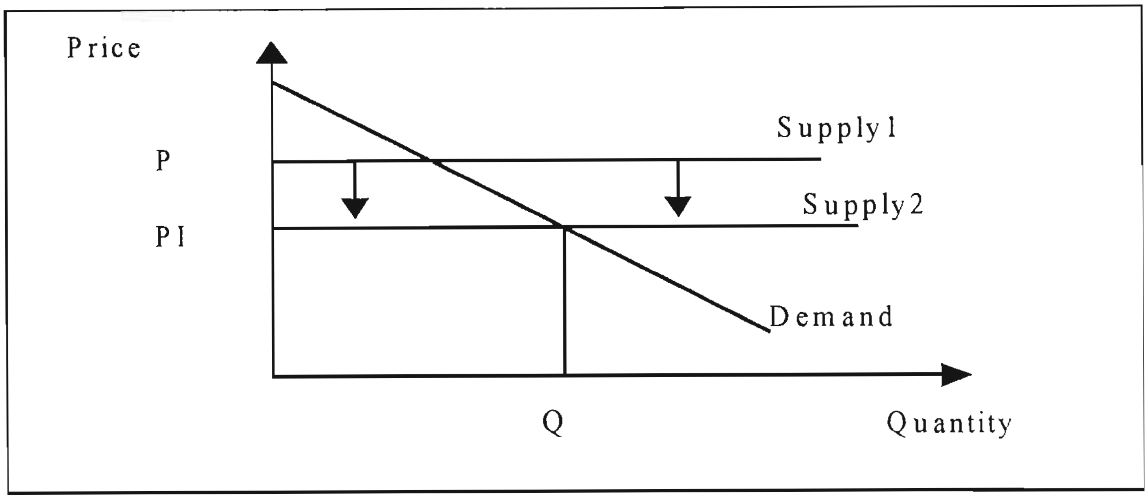

Figure 5-1: Price elastic supply of product intersecting demand curve.
Note: PI is the estimated future price index. Projected consumption is at point Q.

5.3.2.1.1 Poultry

Historically, improvements in time taken for broilers to reach slaughter weight and in the production of breast meat per kg of a whole bird have been achieved. 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 progresses of this nature contributed to a 5% annual growth in world production and price decreases of 4% annually from 1990 to 2000[14]. Future advances are possible although the rate of improvement (especially in terms of days to slaughter weight) is unlikely to be as high (Gous, 2000; McKay, 2000).

Table 5-8 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 5-2). Compound growth rates given by functions (a), (b) and (c) (Table 5-8) 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 5-8), which predicts days to slaughter, is used to calculate a technology index that estimates the future effect of technology[15] as follows:

$$TI_{By} = (1+tgr_B)^n \qquad (15)$$

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.

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

[15] 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%.

Table 5-8: 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).

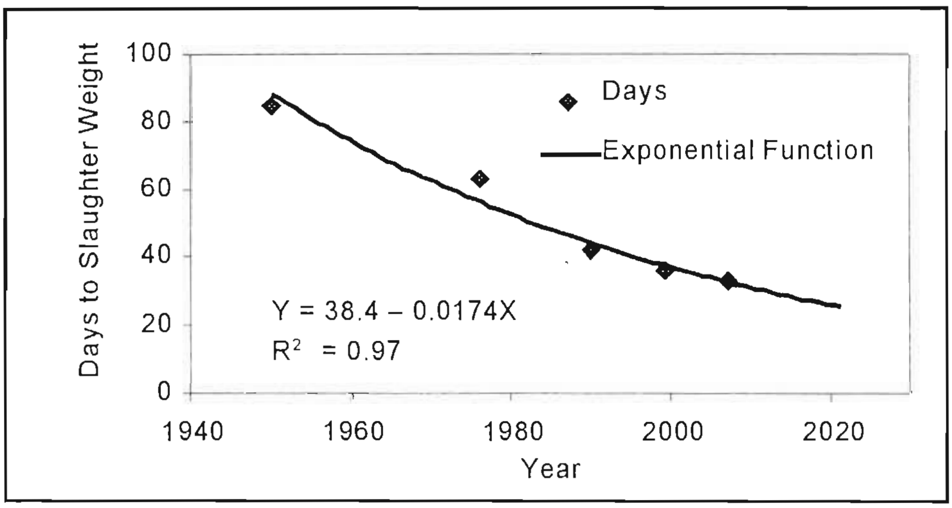

Figure 5-2: Current and projected days to slaughter weight for broilers, 1950 to 2020.
Source: Raw data obtained from Gous (2001); McKay (2001).

5.3.2.1.2 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).

5.3.2.1.3 Pork

From 1990 to 2000 world pork production increased 2.7% annually and prices declined by 4%[16] 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 5-9 shows potential for lean tissue growth in pig production. Nutrient conversion rates remain constant while lean growth rates are 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).

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

Table 5-9: 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

5.3.2.1.4 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 that for pork.

5.3.3 Projected Future Consumption of Livestock Products

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

$$PI_{py} = TI_{py} * IPI_y \qquad (16)$$

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:

$PI_{eggs} = (1.0\text{-}0.0147)^n *IPI_y$ (17)

The effect of projected prices on consumption is calculated as:

$FCon_p= (1 + (PE_p *(PI_p - 100) /100))* DDF_p$ (18)

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 5-6)

Comparing consumption indices (Table 5-10) with demand indices (Table 5-6) 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 5-10: Livestock consumption indices by product (2010 and 2020), assuming constant international 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

5.3.3.1 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: $P = 222 - 1.17(p/q)q$ (low income growth)

Demand Function 2020: $P = 222 - 1.04(p/q)q$ (high income growth)

Price Elasticity of Demand = -0.82 (Table 5-7).

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

5.4 Projecting Future South African Protein Consumption

For products requiring intensive feeding, (i.e. pork, poultry and eggs) the product consumption index (Table 5-10) 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:

5.4.1.1 Beef

In 1998/1999, 518000 (NDA, 2000) 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[17] 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:

$$PconI_{beef} = (((Fcon_{beef}/100 * 518000) - 518000)/90650 + 1) * 100 \qquad (19)$$

Therefore, a 4% increase in beef consumption ($Fcon_{beef}$, for low-income growth is 104) will lead to a 23%[18] 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.

5.4.1.2 Milk

One litre of milk production requires 0.45kg of feed, 12.5% of which is oilcake. In 1998/1999, 2022 million litres (NDA, 2000) of milk were produced and an estimated 341365 tons of protein feed used. Protein feed required is calculated as $(FCon_{milk}/100*2022*10^6 - 2022*10^6)*0.45*0.125/1000)$.

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[17] 3/12*0.7*518000 = 90650

[18] (1.04*518000-518000)/90650 = 23%

Chapter 6

Results and Discussion of South African Protein Meal Demand and Supply Projections

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 6-1). 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.

Expected protein usage for each livestock sector in 2010 and 2020 is shown in Table 6-2, and the indices from which these figure are derived is shown in Appendix G (Table G-3). Annual growth in feed use by the poultry (broilers) sector is high because of relatively large price decreases for poultry, consequently the 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 6-1: 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 Rate (%)	Protein Feed (million Mt)	Annual Growth Rate (%)	Protein Feed (million Mt)	Annual Growth Rate (%)	Protein Feed (million Mt)	Annual Growth Rate (%)
Base Scenario[1]	1.43	1.40	1.54	1.06	1.62	2.65	1.96	2.30
High Population Growth	1.59	2.49	1.83	1.93	1.80	3.72	2.32	3.15
Low Population (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 3% growth in supply. 3 Link to international model with linear supply growth. 4 Uses FCR index described in 6.3.

Table 6-2: Protein usage ('000 tons) in South Africa by product in 2000 and 2020 at high and low income growth rates (Base Scenario).

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

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 6-2).

If the long-term growth in world protein supply of 3% is maintained, world prices are forecasted 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.

6.1 Alternative Scenarios for South African Projections

Due to the uncertainty about the plausibility of some of the assumptions in the earlier analysis, alternative scenarios are presented to simulate different assumptions concerning tariffs, population growth rates, feed conversion ratios and price elasticities of demand.

6.1.1 Meat Tariff Elimination

The SA livestock industry is currently protected by tariffs (Table 6-3), limited by World Trade Organization (WTO) agreements to between 15% and 40%. If 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 index of 100 and tariff of 40, the protected local price index is 140. Eliminating the tariff means that local prices fall from 140 to 100, while the international price index, declines 29% (Table 6-8). 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.

Table 6-3: Impact of eliminating meat import tariffs on local production of livestock products.

	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 WTO.

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 (Coetzee, 2000). 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.

6.1.2 Population Growth: The Potential Impact of AIDS

van Aardt et al (1999) present population projections that they considered to be 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 AIDS impacts are vastly reduced by medical and behavioural factors[19]. The low projections can be considered as a worst case AIDS scenario. Alternative projections by USCensus (2001), that show negative population growth from 2004, were also considered but appear unlikely when compared to van Aardt et al's (1999) low projections. Protein consumption is 7% lower and 19% higher under low and high population growth respectively. It is likely that AIDS will impact negatively on economic growth (UNAIDS, 2000). However, the extent of this effect in SA is not known and hence low-income growth rate projections of 1.43 million tons by 2020 should be considered a worst case AIDS scenario.

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[19] The high population growth projections can be taken as an estimate of population growth without the negative effects of AIDS.

6.1.3 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:

(FCR index / 100) * PconI (20)

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).

6.1.4 Alternative price elasticities of demand

Estimates of price elasticities of demand are not known with certainty, projections were thus run with alternative elasticities estimated by Nieuwoudt (1998a) and Adam (1998). Nieuwoudt's elasticities represent an upper bound and Adam's elasticities a lower bound.

All scenarios displayed in Table 6-1 were run and the results are shown in Table 6-4 and Table 6-5. The percentage differences in total projected protein usage when using these upper and lower bound price elasticities of demand are shown in tables Table 6-6 and Table 6-7. Use of upper bound price elasticities results in higher consumption projections while use of lower price elasticities limits growth in protein usage. This is because the quantity effect of technology-led declining price trends is greater for larger price elasticities. Differences are greater at low income growth rates since a large proportion of any projected increase is a result falling prices. Variation in results is smaller when international prices are higher (linked to international model with linear supply) because price reducing technology effects are negated.

Table 6-4: Estimated consumption of protein feed in South Africa for different scenarios under low and high income growth (2010 and 2020) using Nieuwoudt's (1998) elasticities.

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	1.47	1.64	1.61	1.28	1.65	2.86	2.04	2.50
High Pop. Growth	1.63	2.71	1.90	2.14	1.83	3.92	2.41	3.35
Low Pop. (AIDS worst case)	1.38	1.01	1.49	0.90	1.55	2.23	1.90	2.13
International Link	1.47	1.70	1.64	1.37	1.66	2.92	2.08	2.60
International Link (Linear)	1.46	1.59	1.46	0.79	1.64	2.80	1.85	1.99
No Tariff	1.34	0.71	1.46	0.79	1.48	1.73	1.80	1.85
FCR Improvement	1.39	1.07	1.43	0.68	1.56	2.26	1.79	1.83
No technology effect on Pork.	1.43	1.41	1.54	1.08	1.62	2.64	1.97	2.32

Table 6-5: Estimated consumption of protein feed in South Africa for different scenarios under low and high income growth (2010 and 2020) using Adam's (1998) elasticities.

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	1.40	1.17	1.48	0.85	1.59	2.49	1.90	2.14
High Pop. Growth	1.57	2.31	1.76	1.76	1.78	3.62	2.26	3.02
Low Pop. (AIDS worst case)	1.31	0.48	1.36	0.44	1.49	1.81	1.76	1.75
International Link	1.40	1.20	1.49	0.90	1.60	2.52	1.92	2.20
International Link (Linear)	1.39	1.14	1.40	0.60	1.59	2.46	1.81	1.89
No Tariff	1.27	0.22	1.34	0.36	1.40	1.21	1.67	1.49
FCR Improvement	1.33	0.63	1.32	0.30	1.51	1.93	1.69	1.55
No technology effect on Pork.	1.38	1.02	1.44	0.72	1.57	2.35	1.86	2.03

Table 6-6: Percentage difference (%) in total protein usage between scenarios with Nieuwoudt's elasticities and Table 6-4

	Low Income Growth		High Income Growth	
	2010	2020	2020	2020
Base Scenario	2.8	4.5	1.9	4.1
High Pop. Growth	2.5	3.8	1.7	3.9
Low Pop. (AIDS worst case)	3.0	4.2	2.0	4.4
International Link	2.1	5.1	2.5	4.5
International Link (Linear)	2.1	2.1	1.9	1.6
No Tariff	2.3	4.3	2.8	4.7
FCR Improvement	3.0	4.4	2.0	3.5
No technology effect on Pork.	1.4	3.4	1.9	3.1

Table 6-7: Percentage difference (%) in total protein usage between scenarios with Adam's elasticities and Table 6-4

	Low Income Growth		High Income Growth	
	2010	2020	2020	2020
Base Scenario	-2.1	-3.9	-1.9	-3.1
High Pop. Growth	-1.3	-3.8	-1.1	-2.6
Low Pop. (AIDS)worst case)	-2.2	-4.9	-2.0	-3.3
International Link	-2.8	-4.5	-1.2	-3.5
International Link (Linear)	-2.8	-2.1	-1.2	-0.5
No Tariff	-3.1	-4.3	-2.8	-2.9
FCR Improvement	-1.5	-3.6	-1.3	-2.3
No technology effect on Pork.	-2.1	-3.4	-1.3	-2.6

6.2 Comparison to Other Projections

A comparison of own projections with other sources is shown in Table 6-8. Nieuwoudt assumed that tariffs would 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 6-8). Briedenhann's (2000) projections are similar for base and low population growth.

Table 6-8: Comparison with Own projections with other projections of protein consumption to 2020

	Low Income Growth		High Income Growth	
	Million tons	Annual Growth Rate (%)	Million tons	Annual Growth Rate %
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.

Chapter 7

Effects of Grain Import Tariffs and Possible Future Sources of Feed in South Africa

7.1 Tariffs on soybean products and maize.

The following discussion analyses the effect of tariffs on local prices and the effect that high maize tariffs, relative to tariffs on poultry meat and soymeal may have on the protein industry. November 1999 prices are used to illustrate these effects. Currently the Board on Tariffs and Trade (BTT, 2000) policy is to levy a 6.6% ad valorum tariff on soymeal, the maize tariff is subject to a formula depending on the US dollar price of maize (see Appendix H)

Soybeans and sunflower are the two meal yielding oilseed crops most commonly grown in SA, although soybeans provide a greater amount of higher protein meal than sunflower and are thus of higher value for animal feed. Sunflower is mainly grown for oil content. Soybeans and sunflowers compete with maize in terms of production.

In November 1999 the international price (f.o.b. Gulf) of maize was $84/ton, soybeans $175/ton and soymeal $166/ton (Agrimark, 1999) giving a soybean/maize price ratio of 2.1. The import tariff on maize was $25/ton (R153/ton) on a landed price of R691/ton (import cost = R844) while soymeal landed at about R1323/ton with a 6.6% tariff (import cost R1410) (Agrimark, 1999). Locally the weighted price of yellow maize was at R810/ton and soybeans R1250/ton to R1350/ton, giving a soybean/maize price ratio of

1.5 to 1.6. Internationally the breakeven price ratio for soybeans and maize is around 2[20], in SA it is closer to 2.2 (Greenfield, 1999) and it is expected that the equilibrium price ratio of soybeans to maize would be 2. A ratio of less than 2 means that, in general, farmers favour maize production because maize commands a relatively greater price per ton on the market than soybeans. Given the preceding price ratios, farmers would be encouraged to plant maize rather than soybeans in SA partly due to higher tariffs on maize maintaining a lower soybean to maize price ratio. Reducing the maize tariff may encourage farmers to grow more of a substitute crop, such as soybeans if prices are favourable.

A production shift from maize to soybeans may not be profitable (despite stimulating efforts from the PRT) if price ratios are distorted by tariffs. Increasing tariffs on protein crops (soybeans), in order to correct price ratios, will be harmful to the livestock industry. A large proportion of SA maize is used by the local poultry industry where it makes up a significant cost of production. Griessel (1999) observes that foreign poultry producers (especially the USA) have access to cheaper maize and can thus export competitively priced broiler meat to SA, threatening the local industry an increased soymeal tariff would compound this problem.

7.2 Local versus international protein production

South African oilseed mills and their ability to crush soybeans effectively is unlikely to match international operations because it is more difficult for local producers to capture

[20] Usually, for a given hectare of land, maize yields are double soybean yields.

economies of scale and most local plants are designed to crush sunflower seed. Inefficient mills will be unable to offer soybean producers competitive prices for meal. Furthermore, most local oil demand is satisfied by sunflower oil and soy oil would be a competing product. Internationally a significant proportion of a miller's revenue is obtained from oil. It is possible that local crushers will be unable to obtain profitable prices for soy oil, thus reducing their competitiveness and their ability in to offer local soybean producers reasonable prices.

Locally however about 58% of soybeans are processed for full-fat oilcake by both large commercial concerns and smaller entrepreneurial operators at a farm level. This outcome demonstrates how manufacturers have adapted to local conditions where extracting soy oil may not be profitable. As discussed earlier full-fat rations are sometimes preferred from a nutritional point of view although the high-energy content means maize prices will have a greater effect on full-fat prices. Nevertheless, producing full-fat soy feed enables local manufacturers to differentiate their product from low-cost Argentinean and Brazilian meal. Furthermore, competition from full-fat imports is unlikely because the product cannot be stored for extended periods and is not manufactured in large quantities.

In the long-term, if African per capita incomes grow rapidly demand for edible oil will probably increase at an equivalent rate as edible oil demand growth and income growth are highly correlated (Gay, 2001). Such a scenario could possible present an opportunity for South Africa to take advantage of infrastructure and technological capacity and manufacture oil and meal for African neighbours. Protection from international competition would likely be needed initially and the practice of allowing imports of cheap oilseeds but placing large tariffs on meal and oil, as is common worldwide, might be considered.

In terms of oilseed production, South African average yields have been low, below 2 tons per hectare, although good yields of over 4 tons/ha have been observed on individual farms. South America and USA appear to have a comparative advantage on soybean production. In Africa, Zimbabwean yield potential also exceeds possible yields in SA. It is unlikely that SA could become a competitive exporter of oilseeds although local production of oilseeds and their products, for example full-fat oilcake, are likely to benefit from local research and continue to provide a valuable feed to the livestock sector.

Conclusion

Two interactive spreadsheet models, useful for scenario analysis, were designed to project price and usage of feed protein internationally and in South Africa. The first model projects future international supply of and demand for protein. The demand-side of the model includes as parameters income growth rates, population growth rates and variable income elasticities that decline as incomes rise. Supply is projected by extrapolating past production data using either a linear or constant growth model. Alternatively, the model allows for independent choice of constant supply growth. Price elasticities of supply and demand are used to derive supply and demand curves and thereby to arrive at equilibrium price and consumption.

Base scenario projections indicate that international prices are likely to remain near 1999 levels to 2010 and increase slightly by 2020 in real terms. The real price of protein meal in 2010 is forecasted 1% higher than the 1999 price. By 2020 however a price increase of 22% from 1999 is estimated. Consumption of all meals is projected to increase 38% by 2010 and 78% by 2020. A sensitivity analysis showed that adjusting the price elasticities of demand and supply for meal did not significantly alter projections, although adjusting income elasticities had a pronounced effect on projections.

Employing a linear supply model results in declining rate of supply growth, leading to increasing price from 2010 to 2020. For this reason constant growth supply projections were also considered. If the long-term growth in meal production of 3% is maintained, a

4% price drop is forecasted for 2020. This scenario is considered more likely since a 3% supply growth rate has been achieved historically and capacity for increasing yields and acreage exists globally.

It is noted that meal prices have historically fluctuated more in a single year than the price increase projected to 2020. Furthermore, real prices of commodities, including soybeans and soymeal have declined consistently over the long-term. The relatively stable protein price forecasted to 2020 is significant given this historical trend. It appears as if the long-term trend of declining real oilcake prices is arrested by strong demand growth in developing Asia. Nevertheless, as demonstrated by the use of alternative supply models, prices will continue to decline if supply maintains a constant growth rate in excess of about 2.94%.

The most important region for protein consumption growth is likely to remain developing Asia, especially China, where demand for protein is driven by increasing per capita incomes and a high population base. Projections are sensitive to the income elasticity of demand estimated for China and differing forecasts for protein feed demand in China have significant effects on projected global consumption and price.

An advantage of the spreadsheet model is that a large number of alternative scenarios can be considered. Scenario analysis was used for some of the parameters where data are more uncertain. A worst/best case scenario shows that if positive and negative impacts on income growth and income elasticities in China occur simultaneously that prices are either estimated to be significantly higher or modestly lower.

Supply projections in the model follow a fixed trend, and price is endogenously determined. It is however possible that increased supply, resulting from consecutive good seasons, would depress prices causing production to increase at a rate slower than that built into the model. The limited potential to store protein meal for extended periods may reduce the likelihood of this possibility.

A second model was developed with the aim of estimating South African protein feed requirements to 2020. 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.

Base scenario forecasts indicate potential for increased protein use as SA nears 2020. Under low (high) income growth, meal consumption increases 24% (58%) to 1.54 million tons (1.96 million tons) 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. The impact of AIDS is evident since the high population growth can be considered an AIDS free scenario. A worst case AIDS scenario assumes stable per capita income levels and declining real prices for livestock products, and thus may underestimate the effects of population decimation.

The poultry industry is 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 competitively priced (international market prices) feed is crucial if the industry is to survive. Since large international protein price increases are not expected over the long-term, efforts to stimulate local protein production should focus on achieving 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.

The questions posed in the introduction can be satisfactorily answered with the two models. International meal prices are unlikely to increase dramatically in the long-term. Even if supply growth follows a linear increase, the projected price rise is relatively low when compared to short-term price fluctuations. It is thus believed that over the long-term real import prices will remain relatively stable. Locally the impact of AIDS on potential protein usage is substantial and given recent population forecasts, it appears improbable that increases in protein usage witnessed over the past decade will be maintained. Decision-makers should keep informed of developments in Asian demand, advances in technology that affect supply and effects of AIDS. These factors are of primary importance in the outcome of projections.

Current and future producers of soybeans in South Africa will be unable to match the yields obtained in South and North America and will have to compete by differentiating their product and/or focusing on local or international niche markets. The current practice of processing full fat soybeans, a product not imported, is therefore likely to continue. Local soymeal production is unlikely become internationally competitive as local producers do not have access to the volumes of soybeans necessary to match the returns to scale achieved by overseas producers.

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 formalising important determinants of meal consumption under different scenarios and structuring this information in an easily operable and dynamic spreadsheet decision support system. The

Protein Research Trust is thus assisted in making informed decisions given the expected economic and social conditions.

Summary

South Africa is a net importer of protein meal with 1998 imports exceeding R1 billion. Most protein meal imports are comprised of soybean meal for use in the poultry industry. In recent years South African consumption growth has exceeded growth in production leading to an increased dependence on protein imports.

Internationally the 1990's witnessed considerable change in the oilcake market. Industrialized nations continue as the largest consumers of meat products and therefore of protein feed, although growth in consumption is low. In developing Asia however oilcake usage increased exponentially, growing annually at 5.6% from 1990 to 2000, a per capita consumption growth rate of over 4%. Initially this sudden increase in world demand was not matched by increases in supply, with the result that meal prices reached high levels in 1996/97. Some market commentators, believing that world food production will struggle to meet increased demand, heralded this as the start of a global food environment characterized by shortages and high prices.

The Protein Research Trust is engaged in stimulating the local industry and is aware that increased future world supplies at low prices would render such efforts ineffective and inappropriate. However, high world prices in the future will make imports expensive, especially if the rand continues to depreciate against the dollar. Information regarding the cost of future imports will therefore be valuable in assisting decision-makers with regard to stimulating the South African protein industry.

Two computerized spreadsheet models were developed to make consumption projections and facilitate informed decision making. The first model projects the international supply of and demand for protein meal from a base year, 1999, until 2020. Estimated price elasticities of supply and demand enable the model to project equilibrium consumption and price. The model incorporates as growth parameters: income growth, population growth and income elasticity of demand. It also allows for income elasticities to decline as incomes rise. Demand projections are made for major consumers in the industrial world and those countries identified as having potential for consumption growth in the developing world. Potential for consumption growth is based on population, population growth rates, GDP and GDP growth rates. In order to obtain world supply projections historic world meal production is extrapolated until 2020 using linear or constant growth models. Alternatively, an independently selected growth rate can be used.

Internationally the consumption of protein meal is concentrated in the high-income nations, especially USA and EU who consume over 42% of the worlds protein meal and have the highest per capita consumption levels. Consumption growth rates in these nations have stabilized as consumer demand for meat products has been satisfied. Per capita consumption of protein meal is lower in poorer developing nations although the large human populations in these nations mean that total consumption is significant. Consumption growth rates in developing nations are high particularly in developing Asia where income growth rates are high.

Base scenario projections indicate that international prices are likely to remain near 1999 levels to 2010 and increase slightly by 2020 in real terms. The real price of protein meal in 2010 is forecasted 1% higher than the 1999 price. By 2020 however a price increase of 22% from 1999 is estimated. Consumption of all meals is projected to increase 38% by 2010 and 78% by 2020. A sensitivity analysis showed that adjusting the price elasticities of demand and supply for meal did not significantly alter projections, although adjusting income elasticities had a pronounced effect on projections.

Employing a linear supply model results in declining rate of supply growth, leading to increasing price from 2010 to 2020. For this reason constant growth supply projections were also considered. If the long-term growth in meal production of 3% is maintained, a 4% price drop is forecasted for 2020. This scenario is considered more likely since a 3% supply growth rate has been achieved historically and capacity for increasing yields and acreage exists globally.

It is noted that meal prices have historically fluctuated more in a single year than the price increase projected to 2020. Furthermore, real prices of commodities, particularly soybeans and soymeal have declined consistently over the long-term. The 22% real protein price increase that is forecasted for 2020 is significant given this trend. It appears as if the long-term trend of declining real oilcake prices is arrested by strong demand growth in developing Asia. Nevertheless, as demonstrated by the use of alternative supply models, prices will continue to decline if supply maintains a constant growth rate in excess of about 2.94%.

The second model was developed with the aim of estimating protein feed requirements to 2020. 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.

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. The impact of AIDS is evident since the high population growth can be considered an AIDS free scenario. A worst case 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 AIDS effects is clearly desirable to the livestock and feed industries.

The poultry industry is 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 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.

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Appendix A.

A.1. The Use of Microsoft®Excel 97 as a Modeling Tool.

Microsoft® Excel 97 is a widely used spreadsheet program and is a useful tool for manipulation of numbers, data and formula. Furthermore, Excel 97 offers the object oriented programming language Visual Basic for Applications (VBA). VBA provides user-programmable access to data analysis functions and can be used to automate tasks and to create functional applications.

VBA facilitates the graphical design of programs by allowing the developer to place controls (List boxes, buttons etc) on a sheet or form and linking the controls to relatively simple code. The execution of code is controlled by events that occur at run-time (event-driven). For example clicking a button sends a message to VBA to run a previously written procedure.

In this study, Excel 97 and VBA have been used to design a model that requires numerous calculations and a significant amount of data to make projections. The model can be controlled via the usual Excel 97 graphical interface enabling the user to compare different scenarios by changing the necessary variables at a click of a button. A disk, containing the spreadsheet model is attached (See Appendix I for instructions).

Appendix B.

B.1. Income Elasticities of Demand for Protein Meal

Table B-1: Estimated Income Elasticities of Demand for Protein Meal, using Base Scenario GDP Growth Rates, in 1997, 2010 and 2020.

	1997	2010	2020
United States	0.26	0.26	0.26
Japan	0.26	0.26	0.26
EU	0.26	0.26	0.26
China, Mainland[1]	0.80	0.64	0.51
Indonesia	0.95	0.84	0.73
Malaysia	0.64	0.59	0.52
Philippines	1.03	0.96	0.87
Thailand	0.70	0.49	0.33
Korea South	0.33	0.27	0.27
India	1.15	1.01	0.90
Pakistan	1.22	1.16	1.10
Argentina	0.36	0.27	0.27
Brazil	0.46	0.35	0.26
Mexico	0.60	0.50	0.39

Source: Own calculations using equation (2)

Appendix C.

C.1. International Meat Consumption

Table C-1: Kilogram Per Capita Consumption of Meat Products in 1998

	Beef	Pork	Poultry
United States	42.9	30.2	49.3
Japan	11.4	16.5	14.2
EU	18.2	40.8	20.8
China, Mainland	4.7	35.6	11.7
Korea South	10.8	20.7	11.9
Thailand			13.7
Argentina	57.9		
Mexico		9.6	17.9
Brazil	35.9	9.2	23.9

Source: USDA (1999a)

Appendix D.

D.1. Proof that elasticity for two straight line demand (supply) curves is equal at price p_o when both curves intercept the price axis at the same point.

Consider 2 straight lines, representing demand curves A, with slope A_m, and B with slope B_m. The intercept of both curves is P.

At p_o A is:

1) $p_o = A_m q_1 + P$

B is:

(2) $p_o = B_m q_2 + P$

Therefore:

(3) $A_m q_1 = B_m q_2$

Now elasticity of A, E_A at p_o is $dQ_A/dP_A * p_o/q_1$ and elasticity of B, E_A at p_o is $dQ_B/P_B * p_o/q_2$

Therefore $A_m = 1/E_A * p_o/q_1$ and $B_m = 1/E_B * p_o/q_2$. Substituting into 3:

(4) $(1/E_A * p_o/q_1) * q_1 = (1/E_B * p_o/q_2) * q_2$

This statement is true; therefore the elasticity of demand at point p_o is equal for both demand curves A and B. Similarly for two supply curves with the same intercept the price elasticity is equal at any price

Appendix E.

E.1. Statistics for South African Oilcake Consumption and Production

Table E-1: Local Oilcake (tons) Available for Marketing: 1 April 1998 - 31 March 1999 (marketing season)

Description	Total crop 1998/99	Available for crushing	Conversion rate (seed) %	Oilcake 1998/99
Sunflower	* 667,067	667,000	42%	280,140
Groundnut	65,160	15,374	54%	8,225
Soya	** 200,900	86,000	80%	68,800
- Full fat		101,278	80%	81022
Cotton	76,620	48,848	50%	12,820
- Full fat		25,641	50%	24,424
Canola	33,000	3,500	55%	1,925
- Full fat		29,500	55%	16,225
TOTAL LOCAL OILCAKE		947,641		493,581

Source AFMA (1999)

Table E-2: Oilcake Imports (tons): 1 April 1998 - 31 March 1999

CAKE/SEED	TONS	CONVERSION RATE (SEED)	OILCAKE 1998/99
Sunflower seed	10,884	42%	4,571
Sunflower oilcake	32,184		32,184
Groundnut oilcake	1,828		1,828
Soya oilcake	416,045		416,045
Soya beans	24,296	80%	19,437
Cotton oilcake	74,822		74,822
Cotton seed (3)	61,977	50%	30,989
Other seeds ***	1,205	50%	602
Other oilcakes ***	6,295		6,295
TOTAL IMPORTS			586,773
Local Production			493,581
GRAND TOTAL			1,080,354

Source: AFMA (1999)

Appendix F.

F.1. USDA and FAPRI GDP growth rates.

Table F-1: Comparison of USDA and FAPRI GDP Growth Rates

Source	USDA	USDA	FAPRI	FAPRI	FAPRI	FAPRI
Period or Year	1997-2002	2003-2008	Average 1998-2002	Average 2003-2008	Average to 2010	Average to 2020
World	1.35	1.69	0.81	1.94	1.49	1.68
United States	1.87	1.66	1.54	1.46	1.49	1.48
Japan	0.63	2.16	-1.19	2.60	1.13	1.83
EU	2.31	2.09	2.33	2.39	2.38	2.45
China, Mainland	6.71	6.97	5.12	6.59	5.94	6.05
Indonesia	-2.39	3.18	-2.53	4.55	1.74	2.80
Malaysia	0.70	3.03	-1.88	2.65	0.86	1.54
Philippines	1.16	3.05	-0.61	3.10	1.64	2.23
Thailand	0.40	5.08	0.87	6.44	4.31	4.98
Korea South	1.56	4.68	1.34	5.27	3.74	4.45
India	3.75	4.04	3.73	4.28	4.01	4.02
Pakistan	1.71	1.99	1.95	1.96	1.94	1.98
Argentina	4.01	3.69	2.42	4.88	3.91	4.33
Brazil	2.23	3.39	1.03	3.92	2.78	3.17
Mexico	3.43	2.93	2.44	3.26	2.97	3.24

Source: USDA (1999a), FAPRI (1999) and World Bank (1999)

Growth rates converted to per capita growth rates using population growth rates from World Bank.

Appendix G.

G.1. Elasticity data used in South African Projections and estimated protein consumption indices

Table G-1: 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

Source Nieuwoudt (1998)

Table G-2: Conditional Slutsky price elasticity estimates

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

Source: Adam (1998)

Table G-3: 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.

Appendix H.

H.1. Private Maize Tariff According to the Tariff formula of the Board on Tariffs and Trade

MONITOR PRICE : USA No2 Yellow maize price (21 Day moving average)

Price Level Tariff

Exceeding US$ 110 = Free

Exceeding US$ 100 but not US$ 110 = US$ 5.00/t

Exceeding US$ 90 but not US$ 100 = US$ 15.00/t

Exceeding US$ 80 but not US$ 90 = US$ 25.00/t

Exceeding US$ 70 but not US$ 80 = USA$ 35.00/t

Source: BTT (2000)

Appendix I.

I.1. Using the models "ProjProto" and "SAModel"

The attached disk includes zipped copies of the following files:

ProjProto.xls

SS4.xls

SAModel.xls

All models should be copied, unzipped and saved to the same location. Open ProjProto.xls, an inputbox will ask you where SS4 is saved, type in the directory e.g. C:\Projections\SS4.xls.

In Excel make sure you install the Analysis ToolPak, you must enable it by using the Add-Ins command on the Tools menu. All models should now be functional, the interfaces are simple to understand and should be self explanatory. It is advisable to save backup versions of each model.

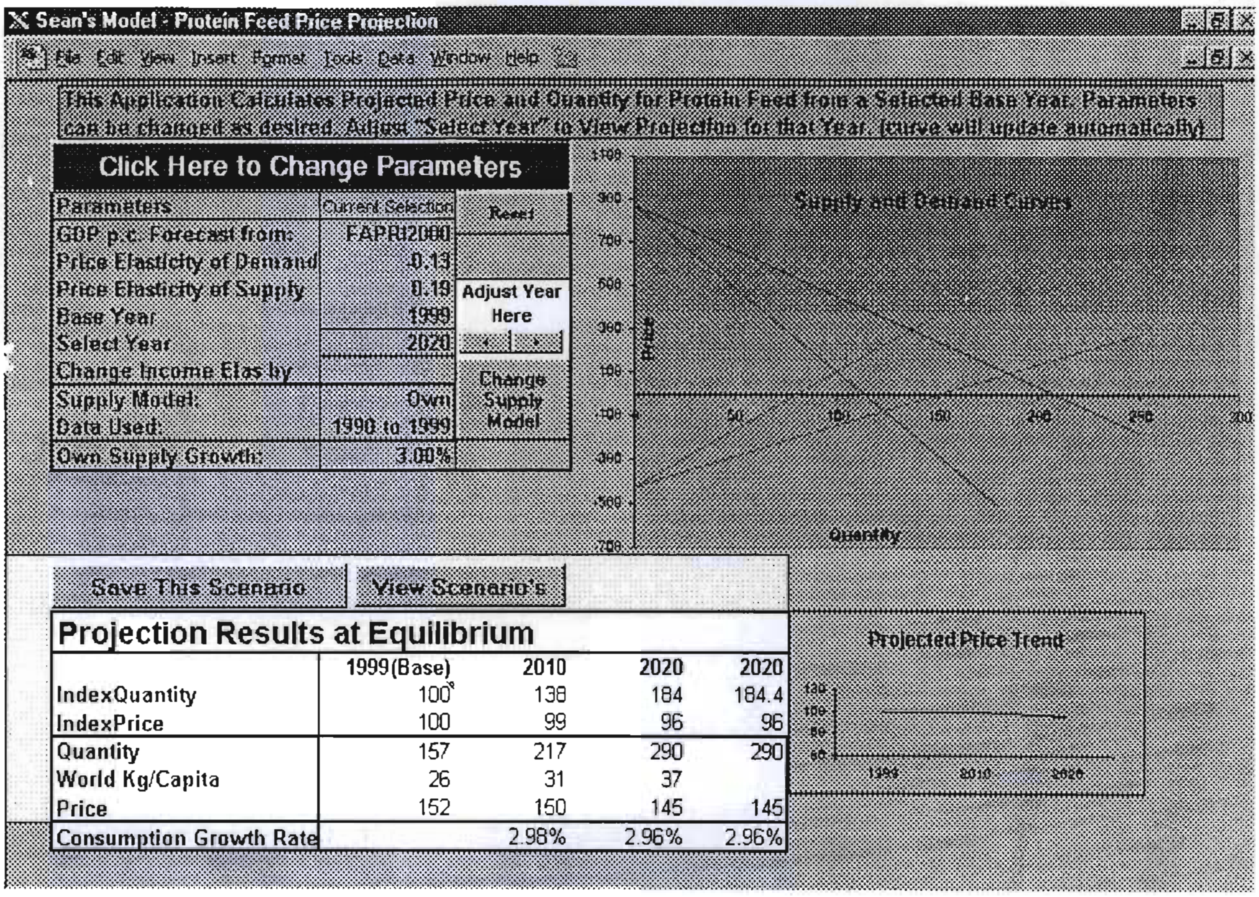

Figure I-1: Main Control page for Projection Model.

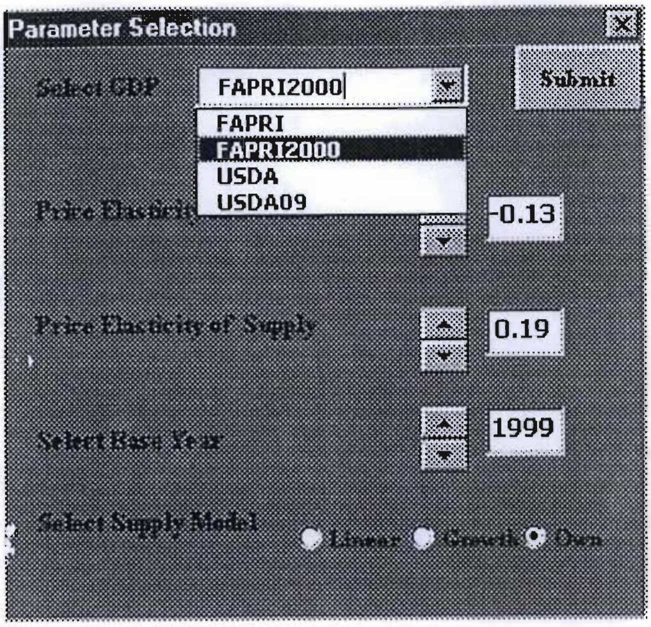

Figure I-2: "Parameter Selection" dialogue box.

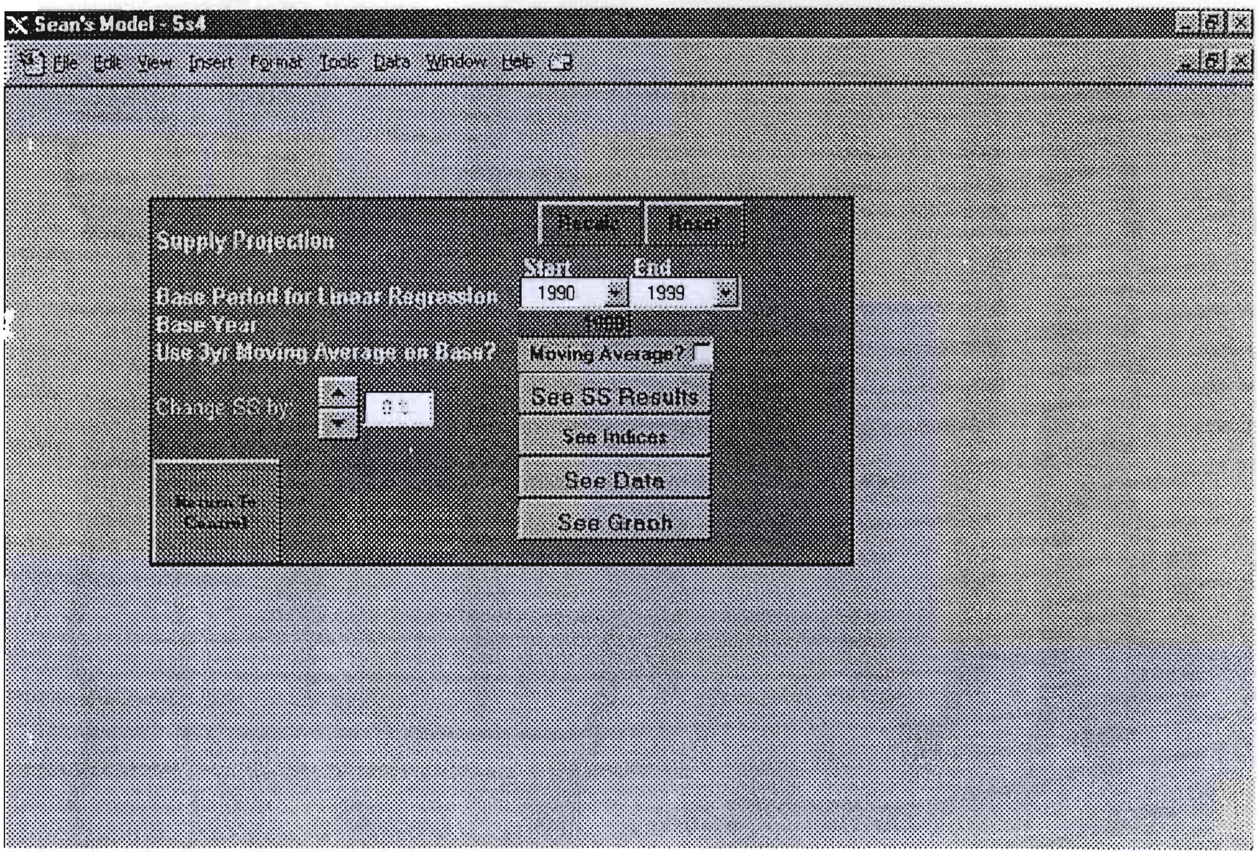

Figure I-3: Spreadsheet Model Control Screen and Model SetUp Form.