A Partial Equilibrium Model for

the South African Broiler Industry

by

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DECLARATION

I declare that the thesis/ dissertation, which I hereby submit for the degree MSc(Agric) Agricultural Economics at the University of Pretoria, is my own work and has not previously been submitted by me for a degree at this or any other tertiary institution.

Signature: Date

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ABSTRACT

The role-players in the South African (SA) agricultural sector have in recent years been increasingly exposed to international agricultural markets and this can have an important impact on them because (1) they are generally price-takers in world markets and (2) the rate of change in agriculture, and the uncertainty arising from it, appears to be accelerating in the global context (Boehlje, et. al., 2001). Therefore, it is critical that role players in the SA agricultural sector, including agribusinesses, farmers and government, are able to anticipate future directions of world markets (Meyer, 2002). A system of econometric models that could be used for scenario planning and improving business strategy and policy development would facilitate this.

A relatively large-scale, multi-sector commodity level econometric simulation model, based on a method of econometric modelling developed and is successfully used by the Food and Agricultural Policy Research Institute (FAPRI) at the University of Missouri, has been developed to describe various agricultural subsectors in South Africa (Meyer, 2006). It is currently housed at the Bureau for Food and Agricultural Policy (BFAP) at the University of Pretoria. The model has a total of 126 equations representing eight crops, five livestock and five dairy commodities, as well as wine, sugar, potatoes and lastly biofuels, which together are referred to as the BFAP Sector Model. The BFAP Sector Model is frequently used for generating baseline projections and conducting a wide range of scenario analysis.

The original or Old Broiler Model, which forms part of the BFAP Sector Model, was constructed in 2003 when the first version of the BFAP Sector Model was developed. Over the past view years there have been a number of occasions where the stability of the broiler model seemed to be questionable, especially when more "drastic scenarios", for example the impact of Avian Influence on the South African broiler industry, were analysed. The original version of the broiler model was not statistically estimated but synthetically constructed, mainly based on sound micro and macro economic principles and theory. The main objective of this dissertation is, therefore, to attempt the construction of an updated broiler model that has improved abilities to generate baseline projections and scenario analysis that capture salient features of the

South African broiler market within the BFAP sector modelling framework. The performance of the updated model is compared to the original broiler model to determine whether the new model is performing better. .

The New Broiler Model is a partial equilibrium model built using new production, consumption, trade and price data as well as a new feed inclusion index. The ordinary least squares (OLS) method was used to estimate the individual equations and their statistical significance was evaluated using typical statistical tests for individual regressions using OLS estimators. These initial tests indicated that the individual equations fit the historical data well, but the per capita consumption and ex abattoir price equations were found to be wanting in terms of their economic significance and especially their ability to generate reliable projections into the future. Consequently the equations were adjusted, thus becoming synthetic equations. The dynamic system structure that resulted from the combination of the individual equations makes it necessary to examine the performance of the overall model when linked to the rest of the BFAP Sector Model. This was done by comparing the results of the Old and New Broiler Models using the baseline projections and performance when dealing with scenario type questions.

The elasticities and the results for the scenario analyses indicate that the New Broiler Model is generally less sensitive to changes in exogenous factors than the Old Broiler Model. The change in closure of the model, from making use the price equilibrator approach to an approach where a net import identity is used, is the most significant change that was made to the model and has introduced a lot more stability in the broiler model and also the BFAP Sector Model. Although the enhanced stability is useful within the context of the total BFAP sector model, the sensitivity that is lost in the New Broiler Model could lead to the underestimation of the impacts of exogenous factors on the broiler industry.

To summarise, this study was conducted for an industry that is characterised by strong and consistent increasing trends in production and consumption in the presence of a constantly decreasing real broiler price. These strong trends influence any form of statistical estimation procedure that is undertaken. To certain degree one can argue, that the key objective of this study, namely to improve the performance and stability of the broiler model within the BFAP sector model was achieved. However, the advantages over the original broiler model are not as clear as was originally anticipated and there is still substantial work that can be done to improve the model. Most of these potential enhancements do, however, require the buy in of various role-players in the broiler industry together with more detailed data sets than those that are currently available.

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

In South Africa (SA) the majority of government interventions aimed at protecting the agricultural sector were abolished with the introduction of the new Marketing of Agricultural Products Act in 1996 (Meyer, 2002). This means that the SA agricultural sector is now exposed to an uncertain environment, which is influenced by dynamic changes in the world economy. This exposure has been magnified through an increase in regional integration through the SADC free trade protocol and the European Union/SA free trade agreement. This increase in exposure to international agricultural markets is particularly important for role players in the majority of SA's agricultural subsectors for two reasons, namely (1) they are generally price-takers in world markets and (2) the rate of change in agriculture, and the uncertainty arising from it, appears to be accelerating in the global context (Boehlje, et. al., 2001). Therefore, it is critical that role players in the SA agricultural sector, including agribusinesses, farmers and government, are able to anticipate future directions of world markets (Meyer, 2002).

A wide range of options based on a variety of approaches, procedures and methods are available to facilitate better decision making (Strauss, 2005). These include modelling and simulation procedures and methods, which can be applied to different agricultural industries or systems, on micro as well as macro levels, in order to gain a better understanding of the impact(s) of exogenous and/or endogenous change(s). This greater understanding of agricultural systems is in turn likely to lead to a deeper understanding of the underlying dynamics and risks inherent to each system and subsystem, as well as improved decision making with regards to business strategy and government policy.

According to Meyer (2002), articles on the development of commodity models and their applications began appearing in economic literature in the mid 1970's. As a result, economists and policy analysts have become increasingly aware of the value that these models can add to understanding and predicting movements in commodity prices, as well as estimating quantities demanded and supplied. In the more recent literature, commodity models have been noted as being a methodological technique that provides a powerful analytical tool for examining the complexities of commodity markets providing a systematic and comprehensive approach to analysing and forecasting market behaviour.

Commodity models have, in fact, been noted to have the capacity to address three important levels of analysis (Poonyth, Van Zyl and Meyer, 2000): (1) market analysis, (2) forecasting of future market prices and quantities and (3) policy analysis. This is on condition that they are developed from high quality empirical research (Meyer, 2002).

In quantitative policy analysis, in particular, two main types of models are used, namely time series projection models and market equilibrium models (Calcaterra, 2002). Time series projection models attempt to forecast the future on the basis of extrapolation of historical data (van Tongeren et al., 2001). These models typically put more emphasis on the statistical behaviour of time series data than on the economic theoretical underpinnings of behavioural equations. Market equilibrium models, on the other hand, contain the response or behaviour of economic agents to changes in output prices/costs (van Tongeren et al., 2001). The objective of these models is the determination of equilibrium prices and quantities on (interrelated) sets of markets. Most large market equilibrium models are often interchangeably referred to as either econometric or econometric/simulation models. This is notable as the term econometric refers to statistically measured relationships and the term simulation means not statistically derived. This indicates that most large equilibrium models contain parameters etc. that are not statistically derived, but are, for example, transformations and technical relationships.

Market equilibrium models can be further categorised as partial equilibrium and economy-wide models (van Tongeren et al., 2001). Partial equilibrium models consider a particular market or sector, e.g. agriculture, to be closed and without linkages to the rest of the economy (Calcaterra, 2002; O'Tool and Matthews, 2002). This means that the underlying assumption is that the sector (e.g. agricultural sector) is affected by the rest of the economy, but it has no direct effect on the economy. The effects of the rest of the world and the local economy on the sector are treated as being exogenous. The advantage of partial equilibrium models is that it is usually possible to represent a particular industry/commodity in much greater detail than is possible in economy-wide models (O'Tool and Matthews, 2002). Economy-wide models, on the other hand, provide a complete representation of a national economy, together with trade relations with other economies, capturing the effects of international trade on the economy in question (Calcaterra, 2002; van Tongeren et al., 2001). Economy-wide models are typically specified as macro-econometric, multi-sector or applied general equilibrium models and input-output models. Economy-wide models thus attempt to describe the entire economic system, representing the direct impact of shocks, e.g. a change in policy, on the relevant market and other areas of the economy, as well as the feedback effects from these to the original market (O'Tool and Mathews, 2002).

The need for a system of econometric models that could be used for scenario planning, improving business strategy and policy development in South Africa's agricultural sector was identified after the disbanding of the agricultural marketing boards. The envisioned system of models would consist of econometric sector level commodity models describing various agricultural commodity markets, as well as farm-level simulation models. A method of econometric modelling, developed and successfully used by the Food and Agricultural Policy Research Institute (FAPRI) at the University of Missouri, was identified as being the most suitable for this purpose. Based on FAPRI's modelling approach, Meyer (2002) developed the first version of a South African econometric sector model for the wheat industry. Meyer and Westhoff (2003) then expanded this model in 2003 to form the South African Grain, Oilseed, Livestock, and Dairy Model (Sector Model). This model is now housed in the Bureau for Food and Agricultural Policy (BFAP) at the University of Pretoria.

Linking the Sector Model to a farm-sector model would enable decision makers to run more comprehensive scenario analyses and to quantify the effect of changes in international and national markets, as well as agricultural and economic policies, on different farm financial ratios, such as profitability and solvency. This model, named FINSIM (Financial Simulation Model) was constructed by Strauss (2005).

According to Meyer (2006), the BFAP Sector Model can be classified as a relatively large-scale, multi-sector commodity level econometric simulation model with a total of 126 equations representing eight crops, five livestock and five dairy commodities, as well as wine, sugar, potatoes and lastly biofuels. A flow diagram illustrating the basic relationships captured within BFAP's Sector Model is illustrated in Figure 1.1. The broiler model is found within the livestock section of the model and is highlighted in yellow. Table 1.1 lists the commodities currently included in the Sector Model.

Figure 1.1: Flow Diagram of BFAP's Sector Model
Source: Meyer, 2006

Table 1.1: Products included in the BFAP Sector Model

Cereals	Oilseeds	Livestock & Dairy	Horticulture& Viticulture	Other
White Maize	Sunflowers	Chicken	Wine	Petrol
Yellow Maize	Sunflower cake	Beef	Potatoes	Diesel
Wheat	Soya beans	Mutton	Sugar	Ethanol
Sorghum	Soya cake	Wool		Biodiesel
Barley	Canola	Pork		DDG
		Eggs		
		Dairy		

Source: Meyer, 2006

1.2 PROBLEM STATEMENT

In 2003 the first version of the South African Grain, Oilseed, Livestock, and Dairy Model, generally known as the BFAP Sector Model, became available. This system of positivistic econometric models was built to provide a means for scenario planning to improve business strategy and policy development in South Africa's agricultural sector (Meyer, 2002). One of the most important industries included in this model is the South African broiler industry, which has been in the top 3 contributors to the agricultural GDP in recent years (DoA, 2008). The broiler model is of particular importance because of its relative size and the resultant sensitivity of other industries to its behaviour.

The original or Old Broiler Model, which forms part of the BFAP Sector Model, was constructed in 2003 when the first version of the BFAP Sector Model was developed. Over the past view years there have been a number of occasions where the stability and thus the simulated results of the broiler model seemed to be questionable, especially when more "drastic scenarios", for example the impact of Avian Influence on the South African broiler industry, were analysed. This created the need to update the existing broiler model by undertaking an in depth review of the broiler industry and applying statistical modelling techniques as far as possible. The original version of the broiler model was not statistically estimated but synthetically constructed, mainly based on sound micro and macro economic principles and theory. As previously mentioned, the broiler industry is amongst the largest agricultural industries in South African and any improvement in the stability and performance of this model will have a positive impact on many of the other commodities included in the larger BFAP Sector Model.

1.3 STUDY OBJECTIVES

The objective of this dissertation is to analyse the structure of the SA broiler industry using economic theory and econometric modelling techniques and then to use this information to update, re-estimate and, where applicable, to refine the existing partial equilibrium broiler model in the BFAP Sector Model. It is hoped that the updated model will provide improvements in the current application of the BFAP Sector Model in the form of:

1. Baseline projections. Baseline projections for the SA broiler industry for the period 2008 -2015.
2. Scenario analysis. Simulations will be run in order to determine the most probable impact of various scenarios on the SA broiler industry for the period 2008- 2015.

The simulation results of the New Broiler Model should be closer to expectations and/or industry fundamentals than those projected using the original version. This will be established by comparing the simulation results of the two versions of the model.

Refining the existing broiler model will include the re-estimation of the parameters included in the BFAP Sector Model, which describe the interactions between the broiler industry and the other industries (such as maize, soya, sunflower, beef and pork) included in the Sector Model and will also incorporate newly identified data that has become available. This means that the inclusion rates used in the broiler feed ration and the total amount of expenditure allocated to feed and other inputs will have to be re-examined. The formation of prices in the model also warrants attention in order to realistically capture the integration between the domestic broiler price and the international price as well as the impact of related meat prices and the dynamics of the domestic demand and supply. In this regard, the use of US broiler prices in the existing broiler model can be called into question as approximately 70% of the imports into the SA broiler market originated from Brazil in 2006 (SAPA, 2008a). Each of the equations contained in the model will have to be examined in this way and it may be decided that new equations need to be added to the model in order to make it more realistic and increase its explanatory power. The final equations included in the New Broiler Model will also be determined by the model closure technique that is identified as the most applicable. This may mean that new equations may be added into the model and old ones excluded.

1.4 RESEARCH METHODOLOGY

One of the most frequently used techniques employed in the study of agricultural policy is econometric modelling (Sckokai, 2001).The Old Broiler Model is a structural commodity model and the New Broiler Model will also be developed using this approach. Initially the Old Broiler Model will be evaluated by examining the performance of equations, comparing projected values and observed values of the dependent variables. Based on the results of this evaluation, the equations that need to be re-estimated will be identified, followed by the identification of the appropriate specifications based on econometric theory (Calcaterra, 2002). New information and data that has been identified or become available since the initial building of the Old Broiler Model will be incorporated as far as possible into the New Broiler Model. The data for this study are secondary data, with the main source of broiler specific data being the National Department of Agriculture (NDA).

The individual equations will be estimated using ordinary least squares, which is a classic econometric technique, along with its associated statistics (for example the R^2 for evaluating goodness of fit, the *t*- test for significance of parameters, and the *F*- test for tests on groups of parameters) (Sckokai, 2001). This means that the following assumptions are included: that the individual equations are linear in the parameters and that there is an absence of cross equation restrictions.

The New Broiler Model will include equations from the Old Broiler Model, which will be updated and where necessary, be modified and if required new equations will be introduced, according to the availability of data and other identified problems in the empirical estimations. The equations which satisfactorily explain the structure and market behaviour of the broiler sector (with the emphasis being on the economic significance of the equations) will be retained and introduced into the BFAP Sector Model. Here they will form part of a system of equations describing several of the larger agricultural industries that make up the Agricultural Sector. In this way the model will simulate/ solve to form part of a recursive system of equations.

It should also be kept in mind that the broiler model will be used for scenario and outlook analysis. This means that there is a trade off between the number of variables and detail that can be included in the model and the availability of data series that can be successively updated.

1.5 STUDY OUTLINE

This dissertation is made up of five chapters, the first of which contains the background, problem statement, objectives and the outline of the study. Chapter Two provides a description of the South African broiler industry. Chapter Three contains (1) a literature review, which looks at previously estimated partial equilibrium model specifications as well as some typical demand, supply and price equations, (2) a description of the data used and (3) the selected estimation method, equations specifications and estimation results. Chapter Four evaluates the performance of the New Broiler Model. It looks at some statistical validation test results, estimated system elasticities and impact multipliers. It also examines the behaviour of the New SA Broiler Model in response to the introduction of shocks into some industry drivers and compares its performance to the Old Broiler Model, using some 'what if' or scenario type questions. A summary of the study and concluding remarks are given in the final chapter, Chapter Five.

CHAPTER 2

AN OVERVIEW OF THE SOUTH AFRICAN BROILER INDUSTRY

2.1 INTRODUCTION

This overview is meant to provide a basic understanding of how the South African broiler market functions, which is essential in order to specify the model correctly so that reality can be simulated as closely as possible (Meyer, 2002 and Strauss, 2005).

The poultry industry consists of three distinctly separate branches, namely the day-old chicken supply industry, the egg industry and the broiler industry (Strauss, 2003). The broiler industry is defined as all the processes and actions revolving around the production, processing, marketing and consumption of chicken meat, while broilers are defined as meat-type chicken strains raised specifically for meat production.

The decision making behaviour of the producers and consumers in the South African broiler industry cannot be fully understood without taking into account changes and developments within the industry, other agricultural subsectors (e.g. maize) and the broader SA economy, as well as the international broiler meat market. This is because agricultural commodity markets reflect a complexity of interrelationships between economic, technical, biological, and institutional factors (Meyer, 2002).

Therefore, the objective of this chapter is to provide a general overview of the international broiler market and a more detailed overview of the SA broiler industry. The international market is discussed first, as developments in the international arena have direct and indirect impacts on the SA broiler industry (du Toit, 2005). It is thus only within the context of the international arena, that the functioning of the SA broiler industry can be truly understood. The second section of this chapter provides an overview of the SA broiler industry, concentrating on domestic consumption, production, trade and prices. Emphasis is placed on the last 10 years as it is felt that they are more representative of how the market currently functions, providing a better and more representative understanding of the market dynamics we are most likely to see in the near future.

2.2 THE INTERNATIONAL BROILER MARKET

2.2.1 INTERNATIONAL BROILER CONSUMPTION

In 1999 the leading importers of fresh and frozen poultry meat were Hong Kong, China, Japan, Germany, United Kingdom, Saudi Arabia, Mexico, Netherlands, Russian Federation and France (Gillin, 2003). In recent years Russia, in particular, has emerged as one of the most important importers of poultry due to rising consumer demand, which has continued to outpace increases in domestic consumption. Figure 2.1 highlights the overall trend of increasing world consumption, together with world trends in imports.

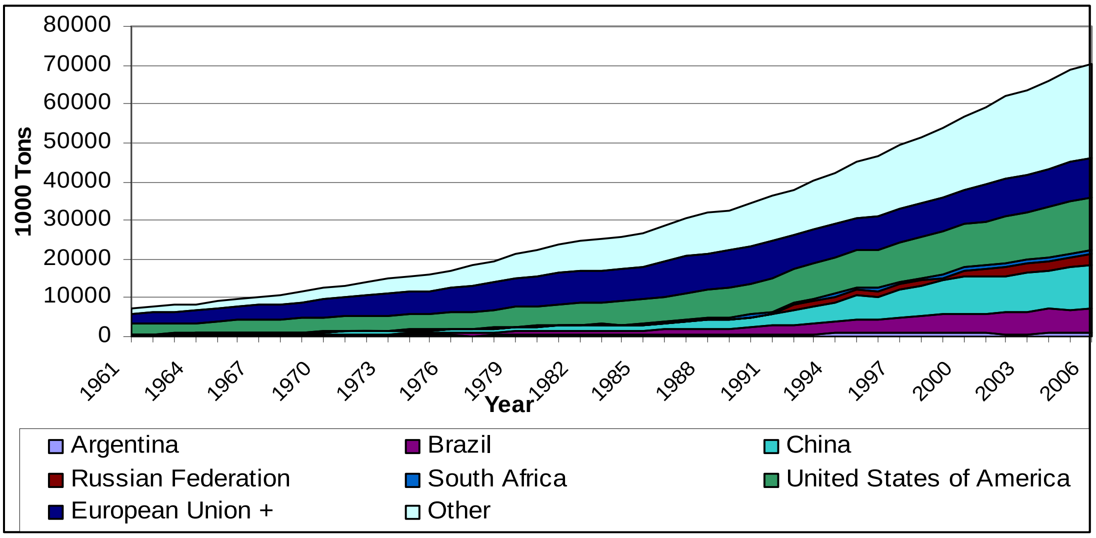

Figure 2.1: Trends in World Broiler Demand
Source: FAOSTAT, 2009

Given the expected economic growth of major world economies, world poultry consumption is expected to grow at a rate that will continue to exceed production and thus resulting in continued drops in world stocks (Makube & Janovsky, 2005).

Countries which demonstrate potential (import markets) are mostly scattered throughout the developing world (Gillin, 2003). These countries include Chile, Peru, Mexico, Pakistan, Iran, Indonesia, Philippines, Nigeria, Algeria and countries in Eastern Europe, as well as Japan. Japanese imports could double in the next 14 years, with China and Thailand probably catering to the Japanese market.

The flexibility of poultry products was well demonstrated during 2004 when, despite negative publicity for a lengthy period of time and consumer concerns about human health, global consumption rose by 1% (Mulder, 2005). An average, higher, growth rate of approximately 2% annually can be expected in coming years (FAPRI, 2007). This trend will be driven by factors including higher per capita incomes, the fact that poultry meat is the cheapest form of animal protein, as well as changing consumer preferences. These factors make it successful in both developing and developed markets and fit in perfectly with modern consumer trends (Mulder, 2005). Another important factor is that poultry has none of the religious restrictions associated with beef and pork. These factors, with the exception of religious restrictions, are elaborated on in the following paragraphs.

Consumers in high-income countries typically face less restrictive budget constraints and lower relative meat prices than consumers in low income countries (Regmi, 2001). As a result, they tend to allocate larger shares of their food budget to meat expenditure. Therefore, one would intuitively expect meat consumption levels to rise as GDP per capita increases in a country, but according to Regmi (2001), it would appear that income levels do not tell the whole story, as consumers allocating budget shares between meat varieties, including beef, chicken, pork, may be influenced by factors such as preference changes, relative prices, and available leisure time. There are also indications that consumers in industrialized nations are willing to pay more for products that feature higher degrees of animal welfare.

Identifying "global" consumer trends really begins with understanding a wide disparity of local consumer behavior (ACNielson, 2002). The key finding of ACNielsen's report for its global study of 2004 is that the fastest-growing food and beverage products are those that support healthy diets, weight loss regimes (particularly high protein-low carbohydrate in North America) and on the go lifestyles

(Anon, 2005). The study found that in 2004 only five categories continued to maintain strong growth (although not double digit), namely frozen fruit, refrigerated salad dressings, fresh ready-to-eat, frozen meat and bottled water. The broiler industry is well positioned to take advantage of both the fresh ready-to-eat and frozen meat markets.

Within the world's fastest growing categories, there are variations in the level of growth between countries. High protein diets have been a popular trend in recent years, particularly in developed countries (ACNielson, 2004). On a global basis, the product area of meat, fish & eggs experienced the fastest growth in sales value over 2003/2004 (ACNielson, 2004). On a regional basis this product area was the fastest growing in both Latin America (at +12%) and North America (at +11%). The Emerging Markets also saw strong growth at +9%, whereas Europe and Asia Pacific had slightly weaker results, each having only +4% growth. A number of categories within this area, which appeal to the high protein-low carbohydrate dieter, experienced good growth for the year. The eggs category experienced the fastest growth at +16%, while frozen meat, refrigerated meat and refrigerated fish/seafood each experienced growth between +6% and +9%.

Within the ready-to-eat meals product area, the fastest and largest sales value growth was experienced by the category of refrigerated complete meals (ACNielson, 2004), especially in the more developed regions of the world (Asia Pacific at +27%, Europe at +12%, North America at +8%). The largest absolute value growth was seen in Europe with an increase of €284.9 million and in North America with an increase of €199.9 million. As broiler (chicken) meat is found in ready-to-eat meals and refrigerated complete meals, this indicates that there is potential for increased global consumption of broiler meat.

Table 2.1: Global Consumer Trends

Category	**Sub-Category**	**Description/ Explanation**	**Example**
1. Consumers' Focus on Health and diet	1.1 Healthy Diet Choices	Given a consumer's diet preferences, certain foods will be perceived as healthy	Popularity of high protein-carbohydrate diets → growth in meat/fish/eggs
	1.2 Healthy Staples	Consumers perceive fruit and vegetables as healthy and increase consumption of these food groups as healthy staples in their diet	Frozen fruit, fresh ready-to-eat salads, fresh vegetables and shelf-stable fruit
	1.3 Healthy Alternatives	Consumers perceive certain products as healthy alternatives for existing products	Healthier cooking oil like olive oil
2. Consumers' Focus on Convenience		Consumers' pace of life is increasingly leading to needs related to convenience: Fragmented eating occasions, eating-on-the-go, outsourcing time and more regular shopping.	Ready-to-eat meals, frozen pizza and portion size drinkable yoghurt products.
3. Growing impact of Supermarket Labels			The proportion of spending on private supermarket label products is 23% in Europe and more than 30% in UK. Private supermarket labels are usually value-for-money discount brands offering an average discount of 50%. (ACNielson, 2005a; ACNielson, 2006).
4. Age complexity			Adults enjoying second youth
5. Gender Complexity			Women moving into male roles
6. Life Stage Complexity			More single person households
7. Income Complexity			Lower income consumers buy selected luxury items ((e.g. premium treats) despite limited budgets
8. Individualism			More personalisation is required
9. Homing			Growing value placed on the importance of the family
10. Connectivity			Being part of a group of friends
11. Sensory Experiences			Seeking sensations and authenticity
12. Slow Food			A movement away from mass/ fast, to closer connectivity with eating pleasure and closer connectivity with the farm / shop owner.

Source: BFAP, 2006; with the data sourced from ACNielson, Datamonitor, Bureau for Market Research and the South African Advertising Research Foundation

Another aspect which has had a pronounced impact on the international market is the preferences of various consumers for specific poultry parts. This has been particularly apparent in US market, where consumers prefer poultry parts that yield white meat as healthier alternatives (Regmi, 2001). The popularity of skinless, boneless chicken breast meat in the United States was facilitated during the late 1980's through technology as well as the advent of convenient preparation and availability, which gave rise to enormous quantities of poultry parts less desirable to U.S. consumers. Large supplies of low-cost, dark U.S. chicken meat, primarily leg quarters, coincided with the relaxation of selected policy constraints to international meat trade and, with growing incomes in parts of the world where consumers prefer dark poultry meat, particularly in Asia and Russia. U.S. trade statistics indicate that Asia and Russia together provide an important outlet for U.S. dark meat parts, which might otherwise be rendered or used as an ingredient in lower value food products. Breast-meat driven poultry production and limited U.S. consumer demand for dark meat parts imply that Asian and Russian buyers effectively face an elastic (excess) supply of U.S. dark meat poultry parts. Domestic prices for dark meat parts would thus probably be lower in the absence of Asian and Russian demand. This has implications for the SA broiler meat industry, which are discussed in Section 2.3.4.

2.2.2 INTERNATIONAL BROILER PRODUCTION, TRADE AND PRICES

According to the FAO, livestock production is growing more quickly than any other agricultural sub-sector and it is predicted that by 2020, livestock will produce more than half of the total global agricultural output in value terms (Vorley, 2003). Global meat production and consumption is also expected to rise, from 233 million tonnes in 2000 to 300 million tones by 2020 (Vorley, 2003), and if established trends continue, poultry and pork meat production will account for the majority of that increase. Poultry's share, in particular, went up from accounting for 13% of world meat production in the mid-1960s, to 28% in the mid-1990s. The different levels of world meat production for the period 1961-2004 are portrayed in Figure 2.2.

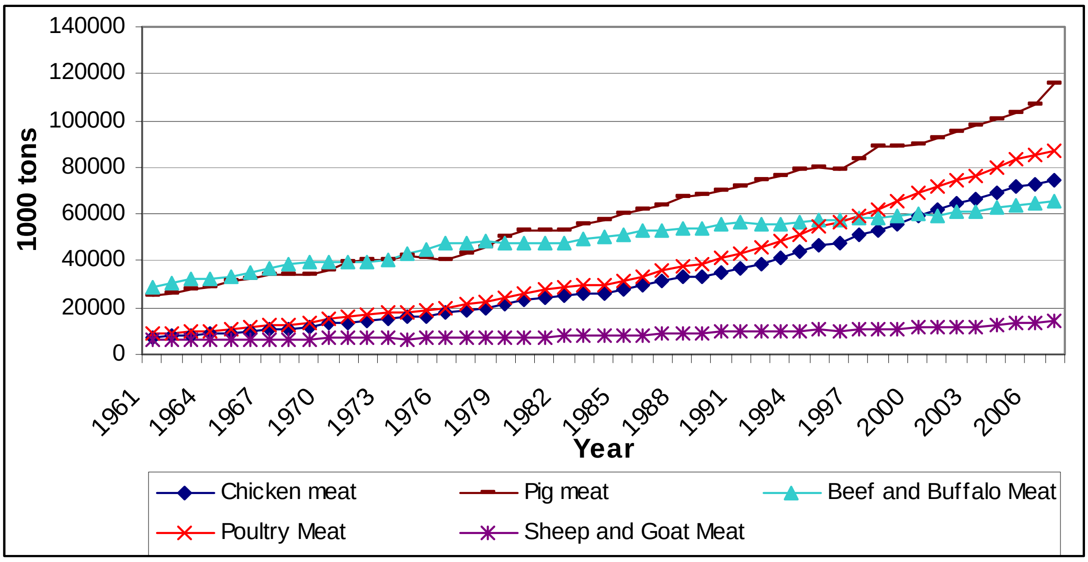

Figure 2.2: World Meat Production
Source: FAOSTAT, 2009 (FAO poultry data also includes turkey, goose meat and other meats such as fowl)

About 86% of poultry meat is currently comprised of chicken meat (Gillin, 2003). This percentage has remained more or less unchanged during the last 40 years, indicating that the other poultry sectors are also doing well. The different levels of global poultry meat production, differentiating between chicken or broiler meat and other types of poultry meat are illustrated in Figure 2.3.

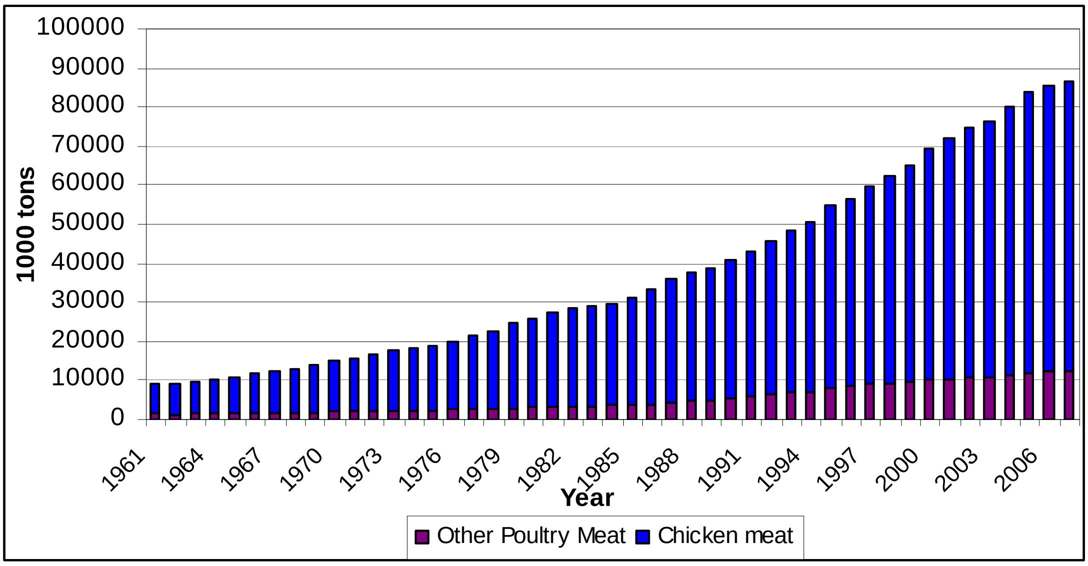

Figure 2.3: World Poultry Production
Source: FAOSTAT, 2009

2.3 THE SOUTH AFRICAN BROILER MARKET

2.3.1 BACKGROUND

The poultry industry in South Africa has grown quite significantly over the past decade to become the largest agricultural industry in terms of gross production value with an estimated contribution of 15.33% in 2006/07 (eggs plus fowls slaughtered) (DoA, 2008), with broiler meat providing the major contribution. Figure 2.4 indicates some of the larger product value categories contributing to the South African agricultural sector's overall Gross Domestic Product (GDP) contribution. It can clearly be seen that fowls slaughtered (the broiler industry) has been either the largest, or one of the largest, contributors to agriculture's gross value over the last 4 years.

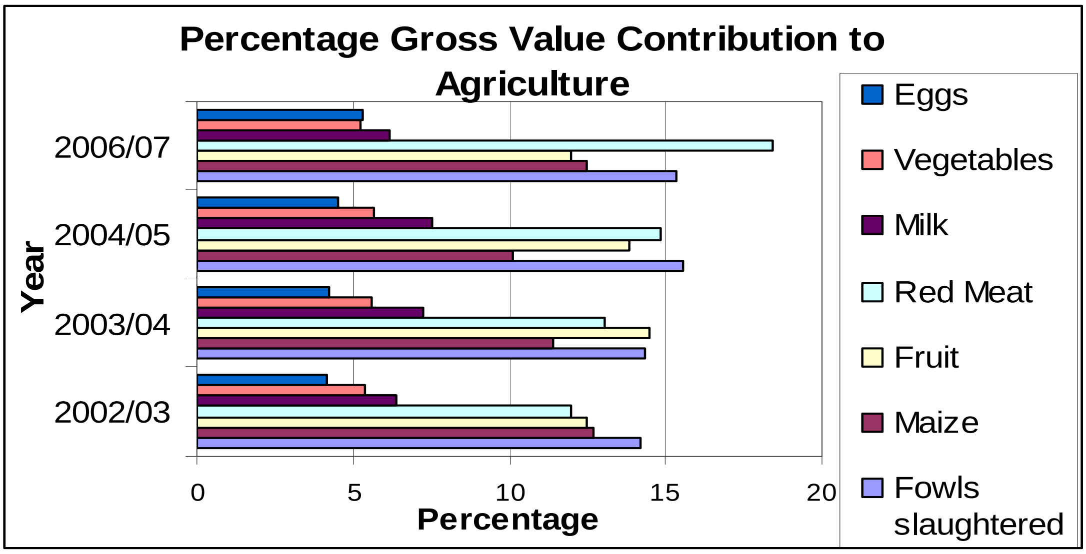

Figure 2.4: Percentage Value Contributions to Agriculture
Source: DoA, 2008

Although the broiler industry has not been directly affected by the Marketing Act of 1937, it was indirectly affected by the overall marketing environment that prevailed (USDA, 1998)[1]. This was particularly true of the Law's impact on most the broiler industry's feed inputs (USDA, 1996; USDA, 1997), most notably the maize industry, as the poultry industry is its largest consumer (USDA, 1996). A new Marketing of

[1] Although the broiler industry was never subject to statutory control under the Marketing Act, it was protected from imports through quantitative import controls (Vink and Kirsten, 2002). These quantitative controls were abandoned in January 1988, when they were replaced by a tariff on prepared or preserved chicken.

Agricultural Products Act was enacted in 1996, which resulted in the closure of the marketing boards around 1997 and put the current agricultural market liberalization process in motion (USDA, 1998). As a result of this change, South African institutions have been forced to review their marketing policies as well as trade protocols, in order to be in line with the new marketing environment and WTO stipulations.

According to the OECD (2006), the measured average level of state intervention in South Africa indicates a relatively moderate degree of policy intervention at the agricultural producer level and an overall reduction since 1994. A comparison of producer support in South Africa and the principal world agricultural players is presented in Figure 2.5. The percentage OECD Producer Support Estimate (PSE)[2] in South Africa is at roughly the same level as non-OECD economies such as Brazil, China, Russia, but slightly above the OECD countries Australia and New-Zealand, which are traditionally the lowest agricultural subsidisers in the world. However, it is well below that calculated for the United States and far below that in the European Union. This conclusion is supported by Vink and Kirsten (2002), who concluded that the output prices that South African farmers receive are market prices, i.e. that they are relatively undistorted by government intervention.

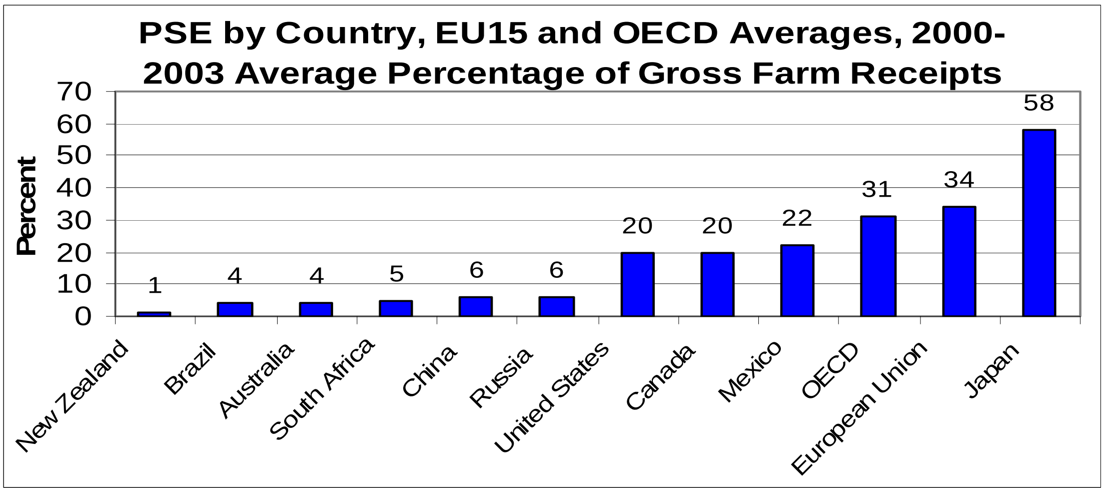

Figure 2.5: Comparison of PSE Values for Various Countries Agricultural Sectors
Source: OECD, 2006

[2] The Producer Support Estimate (PSE) (or Producer Subsidy Equivalent) is an indicator of the level of government support to agriculture in a particular country (Vink and Kirsten, 2002). The PSE indicates the value of the monetary transfer to agriculture resulting from agricultural policies in a given year. It is thus a partial measure of government intervention and has the advantage of allowing cross-country comparisons, as its application and method are monitored internationally.

The marked differences in PSEs for individual agricultural commodities in SA is clearly indicated in Figure 2.6, where the average percentage PSE ranges from 23% for sugar to nearly zero for a range of other commodities (OECD, 2006). Sugar is the most supported commodity receiving support far above the average level of 5%. While commodities such as sheep meat, milk and maize are the other commodities receiving above-average support, their support levels are well below that for sugar and closer to the average level. Support for these commodities is based predominantly on border protection. The egg and poultry industries, however, are in effect taxed according to the PSE estimates shown, despite the border protection granted to the SA broiler industry in the form of tariffs and an anti dumping duty on a tariff line.

Figure 2.6: PSE Estimates for Selected African Agricultural Commodities
Source: OECD 2006

Approximately 55% of total support to agriculture during the period 1994-2003 was delivered in the form of transfers to producers (as measured by the PSEs) (OECD, 2006), while the remaining assistance was provided through general services to the sector. The budgetary spending on general services finances was mainly on research, development and training, investments in infrastructure, inspection and control services, as well as the administration of land reform. Most of these general services (training, infrastructure, etc.) are increasingly targeted to meeting the needs of emerging small-scale farmers, who have benefited from the land reform process.

2.3.2 CONSUMER DEMAND

According to ACNielson (Anon, 2005), consumer demand in SA is somewhat different from the international situation, as there are no commonalities between SA and the global top 7 categories. The 3 top trends in the world, namely health, convenience and private labels are, however present albeit with the provisos. Only consumers with higher-incomes can afford to pay the premium for health and convenience, while private labels, on the other hand, are growing in the form of cheaper alternative brands, which are often brought in exclusively for a specific retail chain (Anon, 2005). The total food and beverage sector, in particular, has grown by

10% since 2002 as the result of the country's general economic well being and commensurate consumer spending and confidence.

The trend in broiler meat consumption compared to other sources of animal protein in SA can clearly be seen in Figure 2.7. Figure 2.7 also clearly illustrates that broiler meat is the largest source of animal protein. This is largely due to the fact that poultry is one of the cheapest sources of animal protein (du Toit, 2005; DoA, 2008). (See also Figure 2.18, with Beef, Pork and Poultry Prices, in Section 2.3.6.)

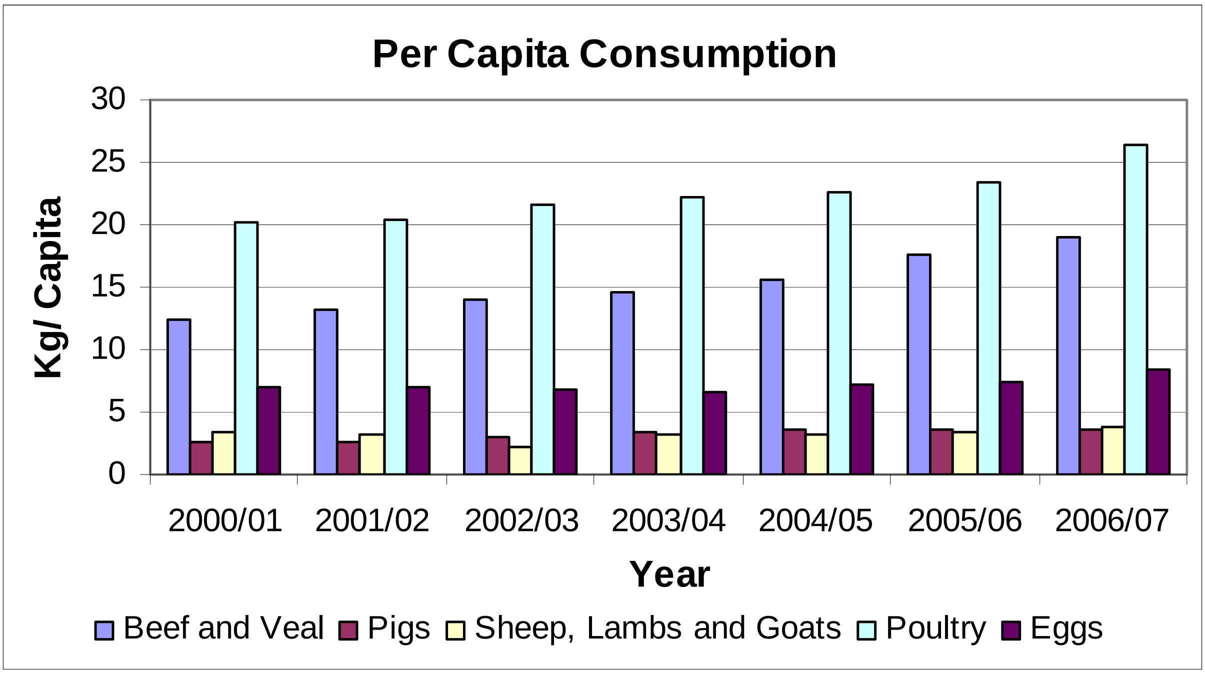

Figure 2.7: Per Capita Consumption of Different Types of Meat in SA
Source: DoA, 2008

In formulating a view on the way forward, however, it is important to look at the duality of the SA consumer market as it has a strong influence on the food consumption patterns observed in the local market (BFAP, 2007). As SA has a diverse population with a wide variety of wealth groups and cultural denominations spread over urban and rural areas, the South African Advertising Research Foundation (SAARF) developed a market segmentation tool, namely the Universal Living Standard Measures (SU-LSM). The SU-LSMs are based on the socio-economic status of an individual or group, with the lowest income or poorest consumers forming the segment SU-LSM 1 and those of the greatest wealth forming SU-LSM 10. The majority of South African consumers (59.3%) fall within the lowest SU-LSM categories, namely SU-LSM 1 to SU-LSM 5.

For low income or poor consumers, SU-LSM's 1-3, the major concern is basic food security i.e. availability of an adequate quantity of affordable food to satisfy basic nutritional requirements (BFAP, 2007). Middle- and high-income consumers, SU-LSM's 4-10, have in turn been found to have food trends based on increasingly complex food requirements, usually reflecting global food consumption trends. SA consumers have, for instance, shown the same need for convenient food purchasing (see Section 2.2.1) and consumption with potential local driving forces being (1) longer working hours, (2) gender complexity - more women entering the work force, (3) time-consuming commuting to work locations. Consumers have also shown a need for improved health through healthy eating and dieting (potential local driving forces being (1) Stressful and busy lifestyles, (2) increased availability of information related to food and health and (3) Globalisation - affecting local consumers' awareness of health-related food issues). An example of the convenience driven consumption trends is the increasing food-away-from-home consumption, both at restaurants and fast food outlets, where the trend appears to be more prominent in the higher income SU-LSM group. This is potentially important for future broiler consumption as broiler meat is a fairly prominent ingredient in the fast food outlets. The following is a breakdown of the trends in meat consumption in the SU-LSMs, which can also be seen in Figure 2.8:

- SU-LSM 1, 2 & 3: Poultry dominates.
- SU-LSM 4 & 5: Beef dominates, followed by poultry.
- SU-LSM 6 & 7: Beef dominates, followed by poultry and mutton.
- SU-LSM 8: Mutton dominates, followed by poultry and beef.
- SU-LSM 9: Poultry and mutton dominates, followed by beef.
- SU-LSM 10: Poultry dominates, followed by beef & mutton.

Of all the animal proteins, chicken is the most versatile with the greatest potential for use in various types of meals, thus appealing to consumers in all of the LSM groupings (SAPA, 2008b). Chicken meat lends itself to be processed in core (whole and portions), value-added (marinated, diced, minced, etc) and further processed (freezer to fryer, fully cooked, emulsified, etc) offerings.

Given these trends, with the increasing size of the middle class and their higher potential expenditure on broiler meat, as well as the increase in the percentage of adults that have access to in-home electricity (an increase of 79.1% to 85% of total adults between 2000 and 2006), refrigerators and microwave ovens, the future growth in broiler consumption appears to be very likely.

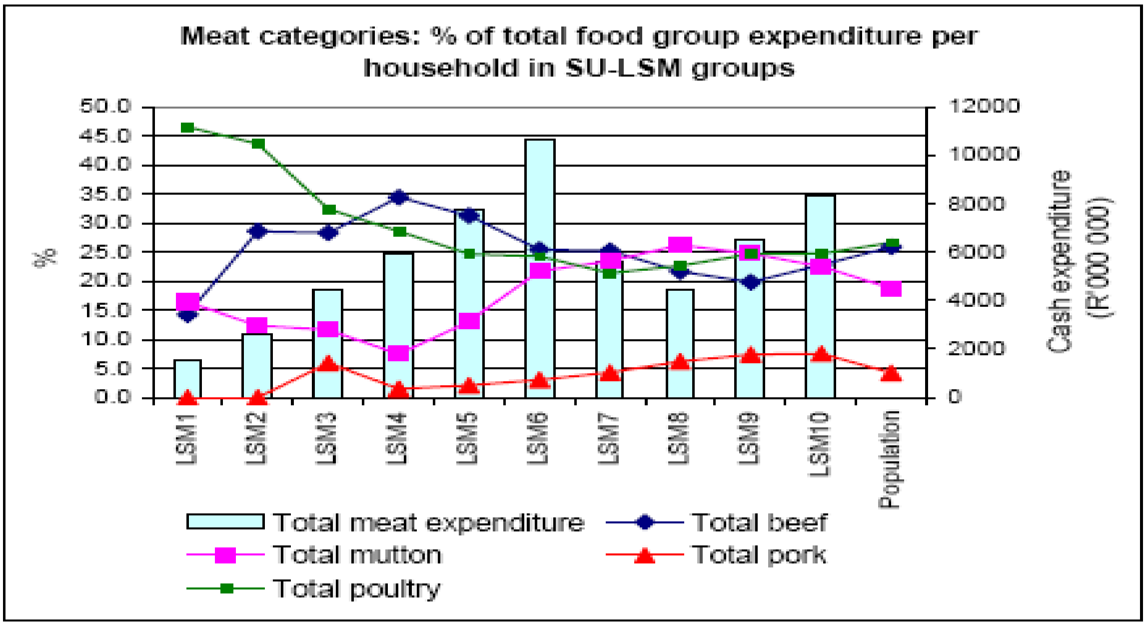

Figure 2.8: Overall Expenditure on Meat Types per Household in SU-LSM Groups
Source: BFAP, 2007, based on data from the S African Advertising Research Foundation

Part of the rise in chicken meat consumption in the last few years results from the broiler industry's response to the demands by consumers and food service operators for value-added, brand name and convenience products, and not only from the commoditised volume products (SAPA, 2008b & SAPA 2009). The continued demand and increase in per capita consumption can still be seen to hold a substantial potential for growth when SAs' per capita consumption of around 25 to 30kg/capita is compared to the per capita consumption in Brazil and the United States, which is in excess of 40 kg (SAPA, 2009).

2.3.3 DOMESTIC PRODUCTION

Recent domestic productions trends for poultry are given in Figure 2.9 as well as figures for imports.

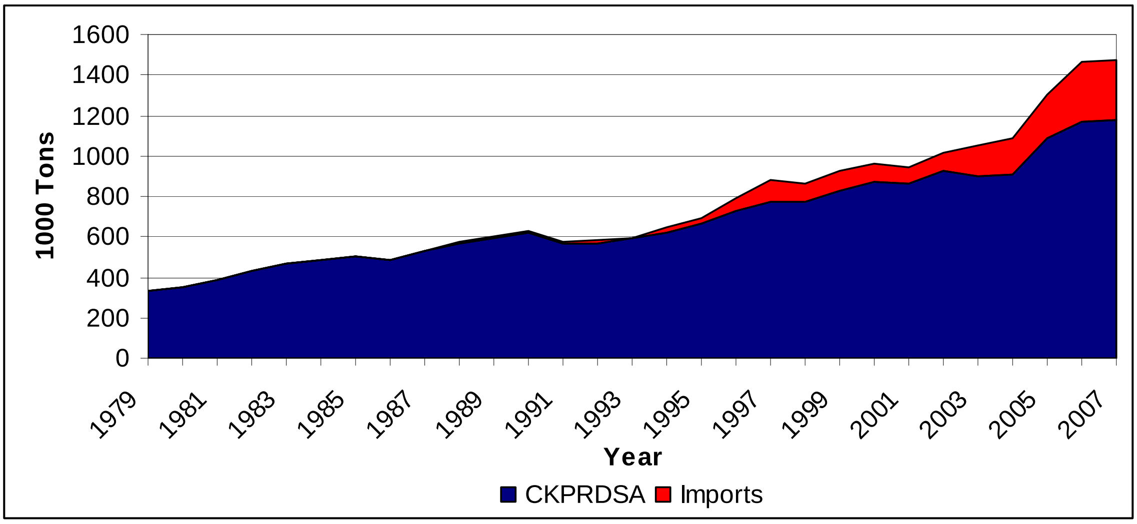

Figure 2.9: The Supply of Broiler Meat in SA
Source: NDA, 2008

Figure 2.10 indicates that between 1992 and 2004 there have been major improvements in Production Efficiency Factor (PEF) values. These have been commensurate with decreases in feed conversion ratios (FCR) (du Toit, 2005), which have decreased to the present level of approximately 1,8. The PEF values as shown in Figure 2.10, have however, improved from 150 to 263 while international PEFs have been constantly represented between 270 and 300 (SAPA, 2008b). The difference can, amongst others be explained by reasons such as the disease pressure experienced in

SA, as well as the high altitude production systems, the current marketing mix in terms of products and weights.

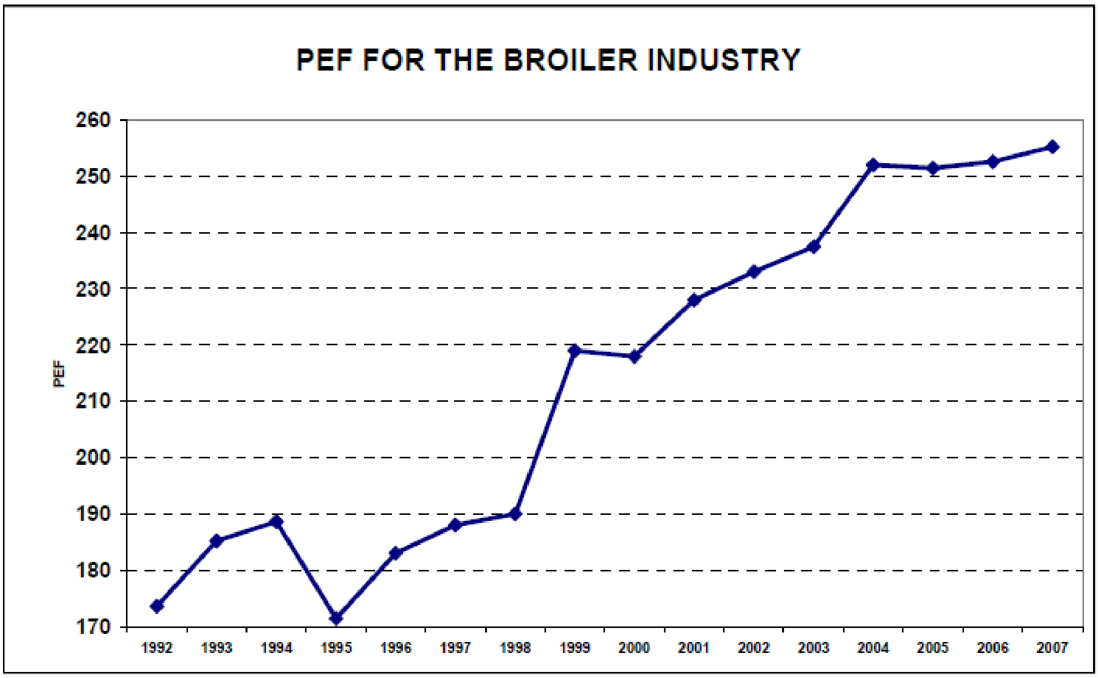

Figure 2.10: Performance Indicators: PEF's and Feed Conversion Ratios
Source: SAPA, 2008b

The mortality rates and boiler age and weight relationships presented in Figures 2.11 and 2.12 also indicate increases in the efficiency of broiler production.

Figure 2.11: Mortalities from 1992 to 2004
Source: du Toit, 2005

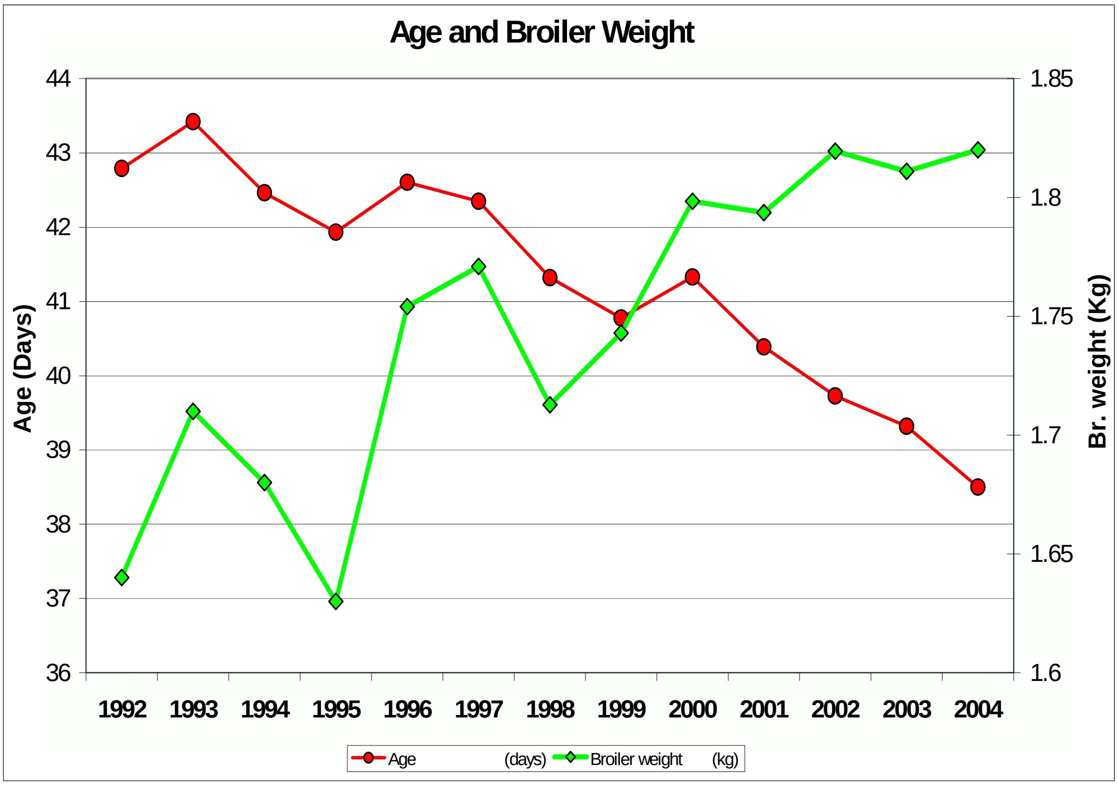

Figure 2.12: The Relationship between Age and Broiler Weight
Source: du Toit, 2005

The broiler industry is made up of a small number of large producers, which constitute the formal sector of broiler production. The degree of dominance and integration of the larger commercial broiler producers is clearly indicated in Figure 2.13. Approximately 77% of consumption is supplied by commercial producers of which there are approximately 551 (including contract growers) (SAPA, 2006). The upcoming informal sector shows a similar trend, with 30 producers producing 93% of the total 3% contribution to consumption, and hundreds supplying the balance. New entrants are, however free to enter with the only limitation being the availability of day-old chicks, capital and expertise.

Figure 2.13: Broiler Industry Flow Diagram
Source: SAPA, 2008b

Although it cannot be seen in the Figure 2.14, the real input price decreases are largely postponed for the majority of the players involved in the poultry industry, as the maize spot prices correlates best with those five months later, due to hedging practices (du Toit, 2005). Feed companies also affect the actual end purchase prices in an effort to make a profit. These feed price increases, along with pressures from retailers, have led to profit margin pressures.

Figure 2.17: Factors in Domestic Consumer Price Formation

Source: SAPA, 2006

2.3.4 IMPORTS

During 1994 and 1995 a loophole in the import regulations was used to import seasoned or marinated products free of duty (USDA, 1996). This trade was curtailed when the import tariffs were adjusted, when the South African Board on Tariffs and Trade announced revised poultry product tariffs in a special Government Gazette on July 7, 1995 (USDA, 1997), which they believed were GATT compliant. The new tariffs included reductions for the categories where the rates were 8c/kg or less to free. The rate on whole frozen birds changed from 225c/kg to 27%, on boneless cuts from 8c/kg to 5% and on other boneless cuts from 313 c/kg to 27%. The biggest change affected the prepared or preserved meat category under code 16.03 where the seasoned category disappeared and an 'other' category was instituted which carried a 27% duty, the same as for whole birds, compared to the previous 8c/kg. The 15% surcharge on the 16.02 category was also kept in place.

These did in fact fall within South Africa's WTO commitments, which included a base rate of duty on chicken products at 150%, and a bound rate at 82%, while on turkeys it was 50% and 37% (USDA, 1999). South Africa's WTO commitments also included Special Safeguard provisions.

According to Vink and Kirsten (2002), the decline in real producer prices of broilers by an average of 17% between January 1998 and August 1999 can largely be attributed to dumping activities. During the same period, real retail prices decreased by only 7.4% per annum on average. The real problem, according to the local industry, was the dark meat bone-in cuts such as leg quarters, thighs and wings (that fall under the "other' import category (USDA, 2002)), which were apparently being imported very cheaply, mainly from the U.S (USDA, 1999). This was despite of an import duty of 220 c/kg being imposed on the tariff line on tariff # 0207.14.90 in September 1997 (see Section 2.2.1).

On July 5, 2000, the South African Government Gazette published a notice of provisional anti-dumping duties on imports of U.S. chicken meat, (0207.14 and 1602.32) (USDA, 2000), with the final report being published after lengthy investigation on 27 December 2000 (USDA, 2002). The normal duty on the #0207.14.90 bone in cuts (USDA, 2003) was (and still is) 220c/kg (USDA, 2001), with the new anti-dumping duties being producer specific on chicken meat produced in the US (USDA, 2000; USDA, 2001; USDA, 2002). Bone in cuts produced by Tyson Foods Inc., is subject to a provisional payment of 224 c/kg; product from the poultry producer, Gold Kist, will pay 245 c/kg; and shipments from all other producers will be charged 725 c/kg. The anti-dumping charge was imposed on top of the current import duty of 220 c/kg (USDA, 2000; USDA, 2001; USDA, 2003). The same anti-dumping levies apply to tariff #16.02.32 (other prepared or preserved meat of poultry) (USDA, 2001).

The provisional anti dumping payments started retrospectively on 5 July 2000 and contributed to higher producer and consumer prices (Vink and Kirsten, 2002) and in turn increased the profitability of the industry (USDA, 2001). The aggregate marketing margin remained largely constant however (Vink and Kirsten, 2002).

In 2004 the strong Rand led to cheaper imports resulting in a record import of broiler meat of approximately 180 030 tons (with almost 20 000 tons in December), which is about 18% of local consumption. Imports therefore became the 3rd largest supplier of broiler meat in SA for 2004 (du Toit, 2005). The growth of imports has continued over recent years and in 2006 more than 250 000 tons of meat were imported (Figure 2.15).

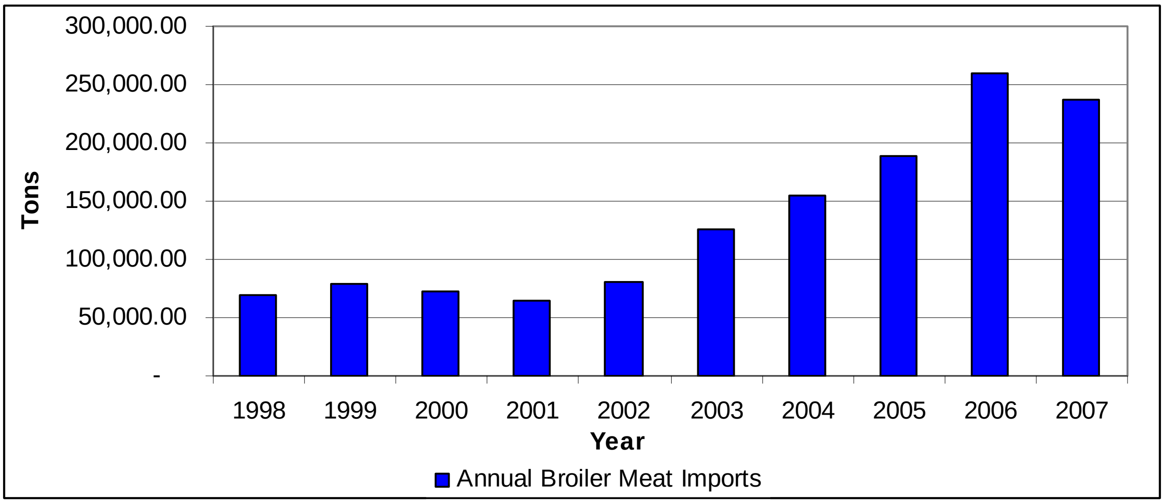

Figure 2.15: Annual Poultry Imports
Source: SACU, 2009

When the anti-dumping duty came under review at the end of 2005, industry players felt that it should be retained as the termination of this duty could result in high levels of USA leg quarter imports, as was the case before its implementation in 2000 (Coetzee, 2005 and du Toit, 2005). The duty is currently still in place (Pressly, 2008).

It is clear from Figure 2.16 that the USA is no longer a large source of imports for the SA market, indicating that the tariff together with the anti-dumping duty for US producers has been effective. It is also clear that the majority of SA imports now originate from Brazil. Brazil is currently considered the least cost broiler producer in the world. The competitiveness of Brazil's broiler industry is derived from a set of advantages detectable across the majority of the supply chain, including production costs and internal availability of soy and maize (Nunes, 2004). These competitive advantages include economies of scale in operations, government support and comparative advantages including climate. One of the main drivers of Brazilian imports is exchange rate strengths (Anon, 2003).

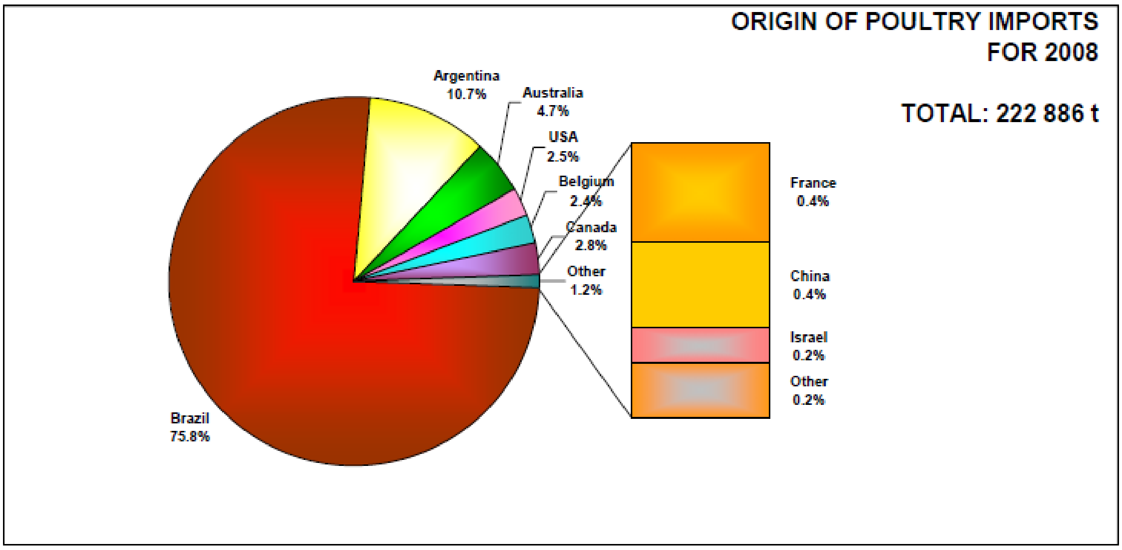

Figure 2.16: The Origin of Poultry Meat Imports for 2008
Source: SAPA, 2009

Overall, developments in the international arena have direct and indirect impacts on the SA broiler industry. Movements in the SA exchange rate, the relative exchange rates between Brazil and the USA, as well as USA policy with regards to a weaker currency in order to stimulate their economy, are all examples of factors affecting the SA broiler market (du Toit, 2005). This is mainly due to imports into the country, which are essentially demand driven. This means that as long as consumer demand continues to outstrip domestic production, which appears to be likely for the near future, imports will continue to play a role in the domestic market, given the current policy environment in SA.

Domestic poultry prices continue to be largely influenced by the Rand / US-Dollar exchange rate and the international poultry prices and will continue to be as long as SA remains a player in the international market. Imports are mostly in the form of dark meat, which is a result of consumer preference between the USA and European consumer and the South African consumer. USA and European consumers prefer chicken breasts (white meat) while the South African consumer prefers leg quarters (dark meat). When there is a surplus of leg quarters on the international market, they can be obtained at competitive prices thereby dampening the domestic prices and resulting in the allegation of dumping. So far international prices have continued to increase (Makube & Janovsky, 2005).

2.3.5 EXPORTS

Throughout the period from 1979 up until 2005, exports have been relatively small in comparison to domestic production and have exhibited a fair amount of inter-annual variation. The period between 1965 and 1987, when SA was a net exporter of broiler meat, shows the highest level of exports. While in 1987, and for several years afterwards, exports were reportedly close to zero. This makes sense in light of the fact that SA became a net importer of broiler meat during this period. Since the early 1990s exports have continued to be small (USDA, 2001; USDA, 2002; USDA, 2004), despite there being no formal restrictions on exports (USDA, 2007). Exports also appeared to be unaffected when the SA government curtailed all export subsidies, which were mainly based on the General Export Incentive Scheme (GEIS), around the beginning of 1997.

Exports have been mainly regional in terms of destination (USDA, 1997; USDA, 2001). This is mostly due to the fact that SA broiler producers exhibit a positive competitive position with the regard to the majority of the SADC members (SAPA, 2006). The possible exceptions are Zambia and Zimbabwe (with Zimbabwe operating under 'normal' political conditions) (NAMC, 2007). Although not apparent in the size of exports, it has been noted that the SADC region is sensitive to the well-being and trends in the SA broiler market as it constitutes approximately 85% of the poultry produced in SADC (SAPA, 2006).

The main driver of exports is the exchange rate (USDA, 2002; USDA, 2004), as it is generally believed that a window of opportunity for South African exports exists when there is a constant decline in currency value (SAPA, 2006; NAMC, 2007). The mechanics are as follows: when the currency devalues, input costs such as feed, which are largely driven by import parity prices, are still factored in at previous price levels due to them being purchased at an earlier point in time (NAMC, 2007). It is estimated that it takes 5 to 7 months for this effect to work through the broiler production and marketing system. After which the rising input costs eventually reduce the window by lowering the potential profit margin and thus lowering the competitiveness of SA exports against other exporting countries, such as Brazil and the US. This means that if the Rand does not depreciate in value again (or continually) this opportunity closes or works through the system more quickly. Thus exports expand dramatically in a declining phase of the rand (2002) and reverse totally when the rand firms in value (2003), as can be seen in Figure 2.17. It takes time to establish oneself as a supplier in the world market, which means that sudden reversals in profitability, and thus supply when the Rand appreciates, seriously inhibit its development. Niches may, to some degree, be used to partly counterbalance this.

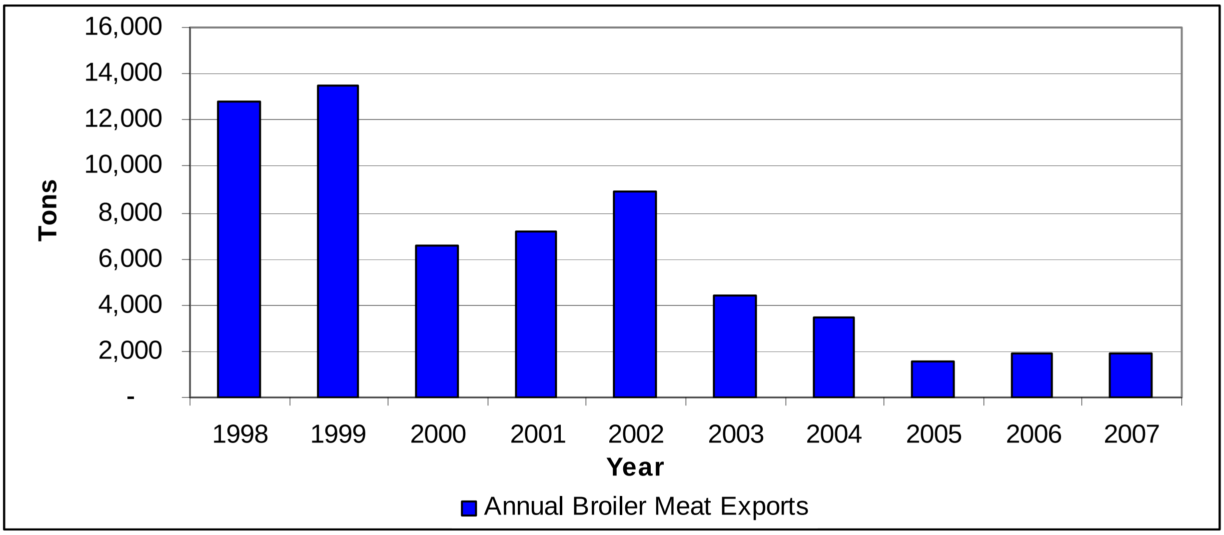

Figure 2.17: Annual Broiler Meat Export Volumes
Source: SAPA, 2006

It is presently the perception among producers that differences in Sanitary and Phytosanitary (SPS) standards for imports and exports are hampering industry performance and that the same stringent standards should be implemented for the verification of imports as exports. The current SPS standards for exports prevent exports to the European Union and the US (SAPA, 2006). There is also a lack of capacity at the provincial level that results in, amongst others, differing levels of efficiency in carrying out export certification and applying general livestock importation standards (NAMC, 2007).

2.3.6 THE DOMESTIC BROILER PRICE

The increase in broiler meat consumption is in large part due to the fact that poultry is one of the cheapest sources of animal protein in SA, as can be seen in Figure 2.18 (Du Toit, 2005). This Figure also highlights the tendency of broiler prices to follow the red meat and pork price cycles, which in turn are linked to the economic cycle and climatic factors (SAPA, 2006). Higher prices are normally reached during Easter and Christmas/New Year, when demand peaks (Strauss, 2003; SAPA, 2006).

Figure 2.18: Beef, Pork and Poultry Prices
Source: SAPA, 2006

There is agreement that there is a feedback component in the relationship between red meat prices (beef prices in particular) and broiler meat prices, but two explanations of possible feedback mechanisms have been put forward. According to SAPA (2006) the broiler meat prices are affected by the red meat prices and beef may be the price leader, where as chicken meat has been listed as the price leader in the meat sector in several USDA attaché reports over the last ten years (USDA, 1996; USDA, 1997).

The idea that red meat, and beef in particular, leads meat prices is based on the belief that consumer preferences have not changed that much over time and that SA consumers still prefer red meat if the price is right (Coetzee, 2007). In addition broiler prices react to changes in the red meat prices on a seasonal as well as cyclical basis (du

Toit, 2005; SAPA, 2006). Thus broiler prices may be seen to depress the overall red meat prices, but may not be the price leader.

The idea that broiler meat is the price leader in the meat sector is motivated using the argument that broiler meat constitutes the largest amount of meat consumed in SA (an observation explained by its relatively cheap prices and changes in consumer preferences, for example, a greater health consciousness (USDA, 1998)), and the fact that the price gap between the different meats has stayed constant when compared to the broiler meat price (USDA, 1996; USDA, 1997). The result is, it is argued, that red meat prices are kept in line (USDA, 1997) through the impact of the relatively cheap broiler prices which, due to their nature of supply, are also seen to be more stable or constant than those of red meats.

Over the years one of the main factors pushing up domestic broiler producer prices has been increases in input costs, particularly feed (USDA, 1996; Vink and Kirsten, 2002). Most of the prices of the feed ration components are in turn heavily influenced by exchange rate movements.

Figure 2.19 highlights domestic producer prices, while giving an indication of the relationship between retail prices as well as the relative value of offal compared to the rest of the carcass.

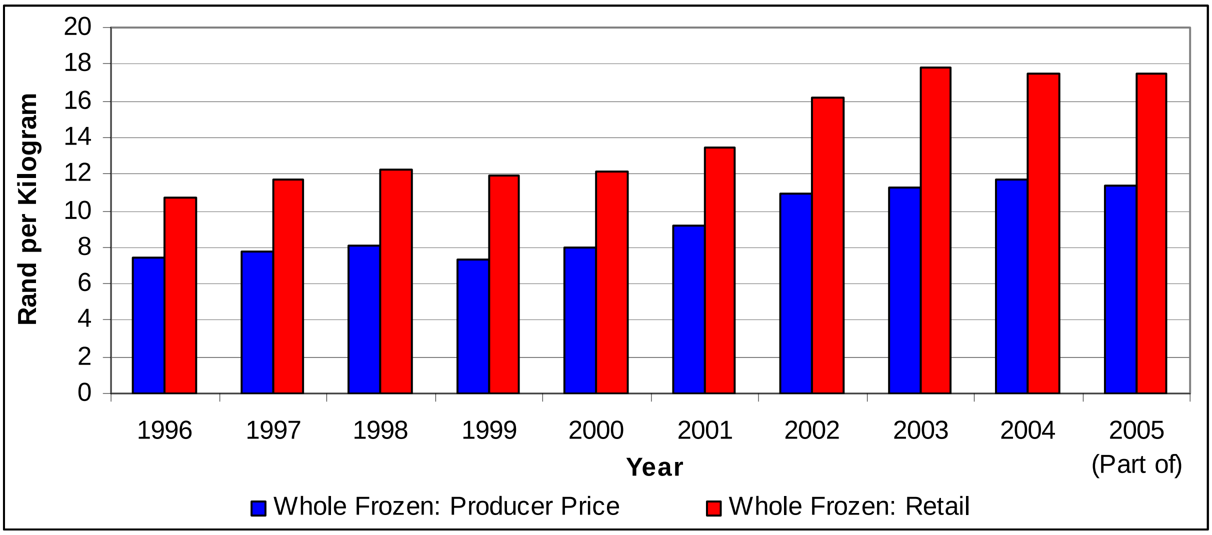

Figure 2.19: Comparison of Domestic Retail and Producer Boiler Prices
Source: du Toit, 2005

International broiler prices and the Rand/ US-Dollar exchange rate are also important factors that influence South Africas' broiler import parity prices (Makube and Janovsky, 2005). This is evident in the decline in broiler import parity prices towards the end of 2003, due to the stronger Rand/ US-Dollar exchange rate, and the following rise at the beginning of 2004 because of higher international prices. The increase in international prices was the result of continued increases in demand. The relationship between USA prices and the SA whole bird price is summarised in the Figure 2.20.

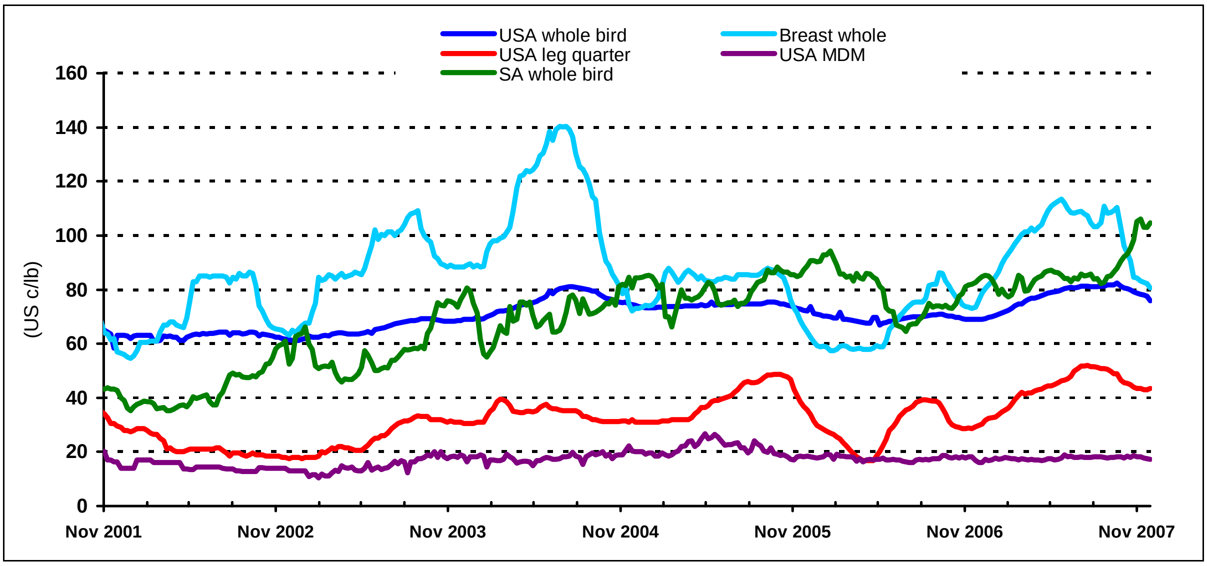

Figure 2.20 Recent International Price Trends
Source: Janovsky, 2008

For many years the argument has been put forward that the downward movement in domestic prices as a result of the impact of import prices and volumes (USDA, 2003; USDA, 1997) has been beneficial for many consumers, especially those who are at the bottom if the country's economic ladder, as they have been able to afford a high quality protein source at relatively reasonable prices (USDA, 1997). This in turn has lead to greater growth in consumption, theoretically expanding the market for local producers. In other words, not only have the cheap imports curtailed food price inflation, but they have also expanded the market. Members of the local industry have, however, expressed concern by this trend in price movements as production costs are constantly increasing. It is not surprising therefore, that United States Department of Agriculture (USDA, 2004) has reported that these movements, have negatively impacted on industry expansion plans. Vink and Kirsten (2002), in turn, have also voiced caution in interpreting data from the broiler industry due to it being supply and demand driven with 18 month lead times for expansion.

As can be seen from the above discussion, the difficulty with establishing a "price" for imports lies in the fact that the imports represent cheaper cuts, offal (NAMC, 2007) and boneless poultry products such as MDM (Mechanically Deboned Meat) (USDA, 1996). If the average declared price of imports (as per bills of entry) for South Africa were to be used, they would be well below the USDA (United States Department of Agriculture) or Urner Barry prices, which are recorded in the US (NAMC, 2007). A total carcass cost, unaffected by market and country specific downward influences, can thus not be obtained by using the reported import prices in Rand and adding freight rates as well as tariffs. Brazilian prices, on the other hand, are generally below US prices as it is the less valued parts that are generally exported to South Africa and have a dampening effect on domestic prices. Because of this and the fact that the majority of imports come from Brazil, these prices should be used in calculating the import parity prices, by incorporating the exchange rate and container freight rate to a CIF (cost insurance and freight) figure, to which the duties can be added in order to get an import parity value.

2.4 CONCLUSION

Over the last several decades the SA broiler industry has structurally changed from a net exporter to a net importer, mainly as a result of domestic demand growing at a faster pace than supply. Unlike many other South African agricultural sub-sectors, the broiler industry has experienced very little direct government intervention in the form of price regulation. There have, however, been several tariffs imposed, as well as an antidumping duty, in approximately the last 10 years. These have, however, not stopped imports, which have a significant impact on price formation. Since there is no indication that consumption will stop growing in the near future, outstripping the growth in production, it appears that the broiler industry will continue to be a net importer for the foreseeable future. The background provided in this chapter will form the basis for the model specification as presented in Chapter 3.

CHAPTER 3

RELATED LITERATURE, MODEL SPECIFICATION AND ESTIMATION RESULTS

3.1 INTRODUCTION

The structure, suitability and use of large partial equilibrium models in quantitative agricultural policy analysis are discussed at the beginning of this chapter. With this background established, the data and methods used in this study are discussed. These sections, together with the industry overview provided in Chapter 2 and the theoretical components presented in Chapter 3 are used to motivate the specification of the New Broiler Model as well as evaluate the estimation results for the individual equations. These sections are important because if the underlying assumptions are incorrect the model will most likely be miss-specified and as a result will not accurately simulate the behaviour of the market, which is the main aim of this study.

3.2 PARTIAL EQUILIBRIUM MODELS

The trend of globalisation in economic activity as well as the simultaneous global orientation of policy discussions is continuing to present an enormous challenge for economists (van Tongeren et al., 2001). The assessment of these phenomena has required the development of global economic models, greatly facilitated through rapid improvements in information and communication technologies. Efforts in global modelling are now well established and have become an integral part of the economics field.

It is important to realise that no single model can fully capture the impacts of complex shocks such as trade agreements (Westhoff et al, 2004). Economy wide general equilibrium models that explicitly account for interactions between agricultural and non-agricultural sectors of the economy have the advantage of containing an overall budget constraint that fully accounts for opportunity costs of resources, as well as linkage(s) between factor income and expenditure (Conforti, 2001). The advantage of partial equilibrium models, on the other hand, is that they allow one to obtain indications of the effects of policies, based on a limited dataset that can not be used in general equilibrium analysis. Therefore it can be argued that partial equilibrium models require less statistical information as they have traditionally focused on a more limited set of variables. As a result modellers have to balance the need for a broad sectoral, commodity, policy, and country scope with that of a detailed coverage of particular market and policies (Westhoff et al., 2004). There are also the costs associated with data collection and processing (Conforti, 2001). This means that the modelling framework adopted should be driven by considerations such as the specific problem at hand, the anticipated solution, the sectoral or regional focus of the potential model, the representation of trade (Oyewumi, 2005) and the costs for data collection and processing.

The advantages and disadvantages of general and partial equilibriums have encouraged the use of partial equilibrium models in sector-specific analyses (Oyewumi, 2005). This has been true for the agricultural sector, especially in instances where it is a relatively small economic sector with limited competition for factor use between it and other industries, particularly as far as land is concerned (Conforti, 2001). This type of sector lends itself to partial equilibrium modelling as, if this condition holds, the effects of agriculture on the economy as a whole can be considered negligible, as can the feedback of such effects on agriculture. The impact of more important occurrences in the economy on the agricultural section can, however, be accounted for at the same time through the use of external shocks.

Partial equilibrium models can be classified as either dynamic or static (Ferris, 1998). Static models tend to be more transparent when looking at structural parameters and provide insights into how policies affect a nation's agriculture. Their design often stems from the need to include many variables, which precludes the complexity that dynamic models introduce. These models generally refer to a single time period, the duration of which depends on the degree of fixity assumed in factor markets, from the treatment of technical change, and from the reliability of behavioural parameters after significant changes in the exogenous variables (Conforti, 2001). Comparative static models are sometimes used to generate projections of policy impacts at some future point in time. Such projections should not to be confused with econometric forecasts, but are achieved by constructing an artificial future dataset that is consistent with the model's assumptions - a so-called baseline - and subsequently conducting a policy experiment on the basis of this projected dataset. The artificial future dataset is constructed by making assumptions on the growth of exogenous variables and parameters and subsequently letting the model solve for an equilibrium that is consistent with these assumptions (Van Tongeren et al, 2001). Comparative static models thus compare the solutions of 2 equilibrium points for 2 different periods in which the level of exogenous variables are different, but do not indicate the adjustment path of the endogenous variables from one time period to another (Conforti, 2001; Van Tongeren et al, 2001).

In dynamic models the definition of several reference periods is frequently used for simulations, as this gives researchers the possibility to take the adjustment of endogenous variables into account (Conforti, 2001). Dynamic models allow the analysis of lagged transmissions and adjustment processes over time (Van Tongeren et al, 2001). These models can, as a result, be used to trace the accumulation of stock variables as well as generate alternative endogenous growth rates, which static models are unable to do. This is important as the implications of accumulating commodity stocks and other growth rates may be relevant for short-run agricultural analysis and allow for lasting effects in long-run analysis, e.g. the impact of an agricultural policy. Dynamic features can be incorporated in equilibrium models in several ways, with the most frequent approach being to specify a recursive sequence of temporary equilibria. That is, in each time period the model is solved to reach equilibrium, given the exogenous conditions prevailing for that particular period. Stock variables are updated, either exogenously (e.g. population) or as a result of the equilibrium outcomes of the preceding period. Recursive dynamics do not guarantee time-consistent behaviour, but are usually tantamount to using rational expectation assumptions. Furthermore, by modelling the intertemporal equilibrium behaviour of economic agents, as well as equilibria within periods, such models are able to counteract the Lucas (1976)[3] critique on economic models.

Despite the specificity characterising the databases used in various econometric studies, it is nevertheless possible to distinguish at least two main types of information, namely aggregate information and that referring to single decision-making units (Sckokai, 2001). Aggregate data usually comes from official statistical sources and consists of time series, normally annual and referring to large territorial aggregates (e.g. the European Union or an individual country), for which the total values for flow and/or stock variables are recorded with some form of average values (or indices) as regards prices. Many of the econometric studies in the agricultural sector have been developed using this type of data. The main practical reasons for this being the lack of available data, the limited number of observations recorded and the guarantee of reasonable computing times for complex econometric treatment. The data referring to individual units come from sample surveys that, for the agricultural sector, typically focus on agricultural firms. Despite the above mentioned data constraints, there is clearly a general tendency towards the increasing use of data for individual decision-taking units, since it ensures greater adherence to the reality of the economic mechanisms connected with the use of agricultural policy instruments.

Most partial equilibrium models tend to focus on the demand and supply relations of raw agricultural materials or primary commodities and do not explicitly look at value added beyond basic processing (Oyewumi, 2005; Westhoff et al, 2004) and distribution (Oyewumi, 2005) despite the higher share of secondary commodities in agricultural trade. According to Oweyumi (2005), some more recent partial equilibrium models, such as WATSIM and @2030, take the linkages between the primary and secondary commodities into account through the introduction of technical coefficients, which handle the conversion of primary to secondary products. Partial equilibrium models today typically include oil and meal from processed oilseeds, meat from live animals, dairy products from milk and raw sugar from sugar

[3] Where according to Marcellino and Salmon (2001), the critique is essentially captured in the following quote from Lucas's 1976 paper: "Given that the structure of an econometric model consists of optimal decision rules for economic agents, and that optimal decision rules vary systematically with changes in the structure of series relevant to the decision maker, it allows that any change in policy will systematically alter the structure of econometric models.".

beets and cane (Westhoff et al., 2004), with varying degrees of detail. Other products, such as refined sugar and cotton are less frequently included, while vegetables, fruit, wine and other Mediterranean goods are nearly always omitted (Conforti, 2001). These models still do not take into account much of the value that is added through further processing and then in retailing and as a result the models do not reflect the true choice set for consumers (Westhoff et al., 2004), i.e. each of the commodity groupings mentioned tends to be seen as being homogenous (Van Tongeren et al, 2001). This simplifies the trade modelling considerably, but creates severe limitations for applied trade research as they lack explanatory power in terms of intra-industry trade, an important phenomenon as even at high levels of disaggregation countries report both exports and imports for many sectors. It is due to the limited coverage of value-added products in these models, that analysts are not always able to capture the impacts of policy changes such as tariff escalations and proposals to reduce escalations, such as those suggested in trade agreements like the Doha modalities (Westhoff et al, 2004).

Even the most complex models fail to capture all the nuances of current policies, and agreements are implemented in various ways (Westhoff et al, 2004). Bound tariffs are not the same as applied tariffs and as applied tariffs decline, non-tariff measures become more important. This is notable as, except for quantitative restrictions, relatively little attention has been given to quantification of non-tariff measures in agricultural and food product trade. Overall policies are generally not as simple as modellers assume. Often the analysis is undertaken before the modalities of the agreement are spelled out, and it can be difficult to find current data and or information on policy parameters. Further, analysts and their models must recognize that governments typically try to find ways to implement agreements that minimize harm to influential groups. Problems may range from insufficient model detail to changes in agent behaviour under a new trade regime, resulting in estimated model parameters from time-series data having limited relevance. Analysts need to decide whether and how to introduce judgment and/or other extra-model information. In particular, the broad involvement of experts, leaders, and other authoritative individuals in long-range projection programmes can provide important outputs, in terms of both projections and processes (Ferris, 1998). Where this approach is followed, decision makers become "part owners" of the outcomes, changing the impact that such work can have from being merely an academic exercise to a tool that can actively inform and change the way an industry functions.

A limitation of partial equilibrium models is sometimes referred to as "Metrics for measuring the impact of reforms" (Westhoff et al, 2004). This refers to the fact that in order to give an indication of the impact of policy change(s) or reform(s), most modellers report the impacts on market prices and quantities, trade flows, farm returns, and government budgets. These measurements may address the concerns of some stakeholders, such as farm interests and policy makers, but ignore other metrics such as welfare measures of aggregate gains and transfers among groups, which may be important to other stakeholders such as consumers, environmental groups, non-governmental development organizations, and various foreign stakeholders.

One of the limitations of the available analyses stems from the fact that the majority of studies deal with modelling a single problem and/or a single instrument of agricultural policy (Sckokai, 2001). The main objective of most new studies is to extend a standard model so as to incorporate new agricultural policy instruments. Once such extensions have become common practice, the natural development will be to set up models that take into consideration several aspects at the same time (e.g. price uncertainty, production quotas, direct subsidies and set-asides) and, since the instruments generally concern different products, these models will also have a higher level of disaggregation, making it possible to highlight more of the important "cross" effects. This course of action implies a number of technical difficulties, and it is likely that one would have to postulate some simplifying hypotheses in other parts of the modelling work (for example, by imposing restrictions on production technology). In spite of these difficulties, in terms of future simulation work this does seem to be the way forward.

The contribution of econometric models to quantitative agricultural policy analyses has been important (Sckokai, 2001). There is, however, a lot of work that can be done, not only on the modelling of agricultural policy tools, but on data collection, improving the quality of parameters and functional forms (Conforti, 2001). Work on these issues is crucial, since they directly affect the accuracy and the reliability of the results of these models.

The New Broiler Model is specified as an industry specific partial equilibrium model, that in turn forms part of a larger agricultural sector partial equilibrium model. The New Broiler Model is specified as an annual, structural model that is dynamic in nature, in order to fit into the BFAP Sector Model. The aim of the model is to describe the behaviour of a national industry and as a result is not a study of the behaviour of an individual decision making unit. Similar to many previous studies using the partial equilibrium approach, the New Broiler Model will focus on primary production and not explicitly take into account or look at value added processing in the SA broiler industry. In these aspects of classification and specification the New Broiler Model is not different to the Old Broiler Model.

3.3 DATA

That the main aim of this study is to improve the accuracy and realistic representation of the South African broiler industry in the BFAP Sector Model, through the re-estimation of the already existing partial equilibrium Broiler Model. The initial intention was not only to re-estimate the existing equations, but to add in more descriptive power through the addition of more detailed and less aggregated data for the industry. Unfortunately, in many cases the required data was not available in the public domain as the broiler industry is highly competitive and much of the data is confidential. For example, the calculation of representative import parity prices proved to be a real challenge since time series data on exactly which cuts where imported at what transportation costs, insurance and other transaction costs was not available. However, some detailed information could be obtained for periods of time shorter than that required for estimation purposes and was available on a monthly or quarterly basis for some, but not all the explanatory variables. In addition data sets sourced from different organisations have different values for the same variables. This can be seen below in Figures 3.1, 3.2, 3.3 and 3.4.

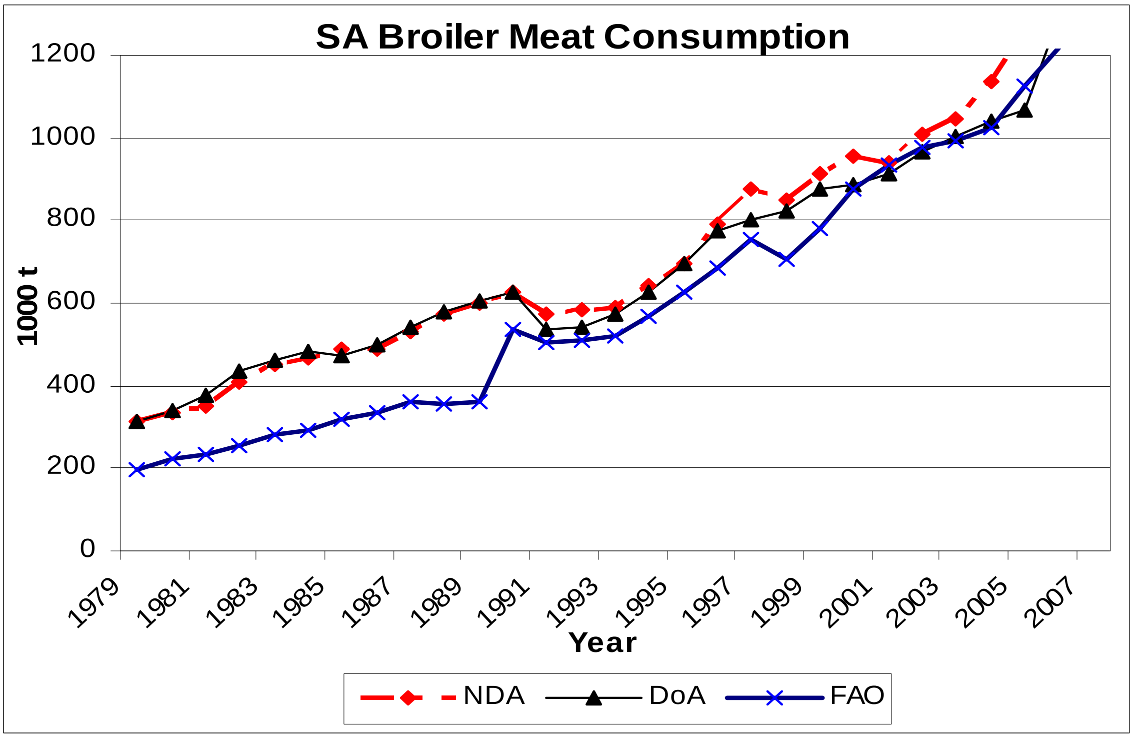

Figure 3.1: Total Annual Broiler Meat Consumption
Source: NDA, 2009[4]; DoA, 2008; FAOSTAT, 2009

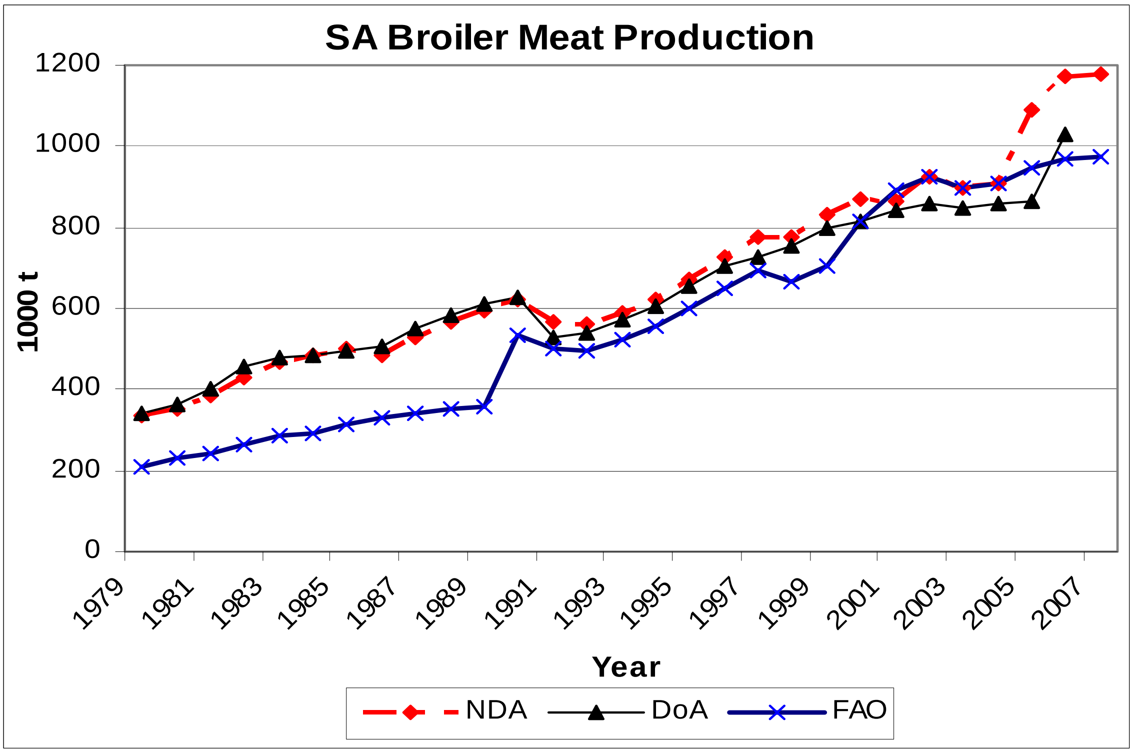

Figure 3.2: Total Annual Broiler Meat Production
Source: NDA, 2009; DoA, 2008; FAOSTAT, 2009

[4] The DoA data refers to the data that is published in the Agricultural Abstract by the Department of Agriculture, while the NDA (National Department of Agriculture) denotes a data series obtained directly from the National Department of Agriculture that has not previously been published.

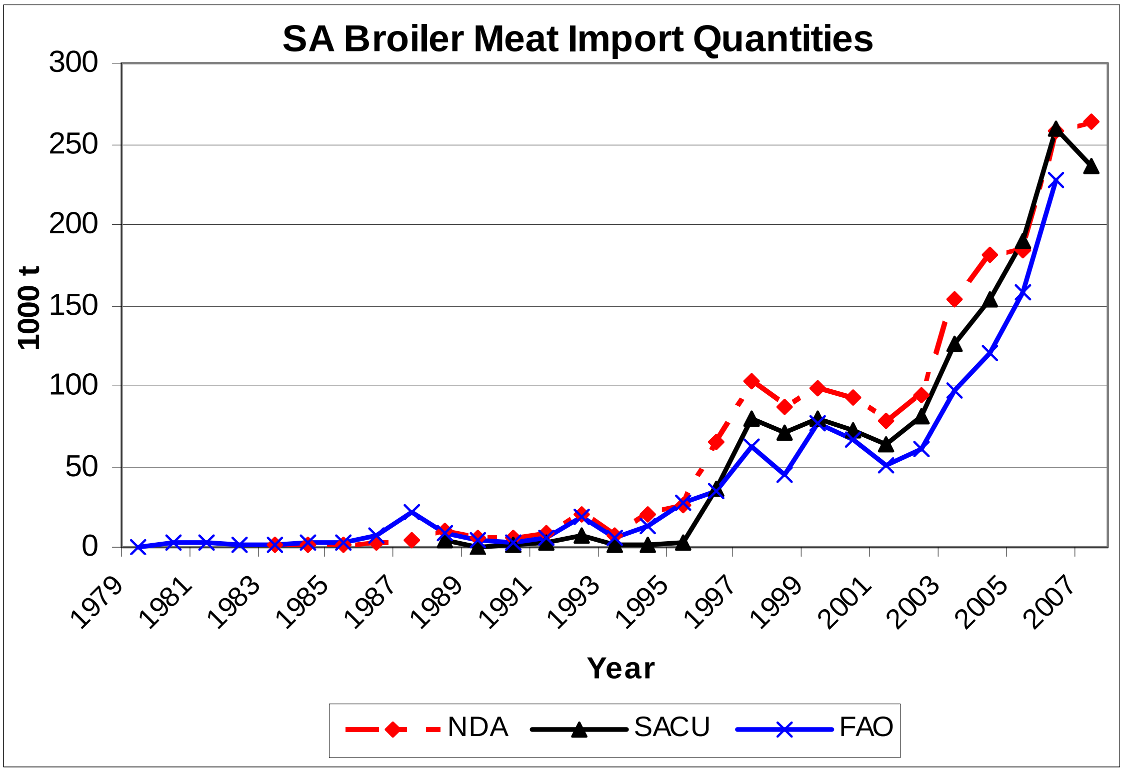

Figure 3.3: Total Annual Broiler Meat Imports
Source: NDA, 2009; SACU, 2009; FAOSTAT, 2009

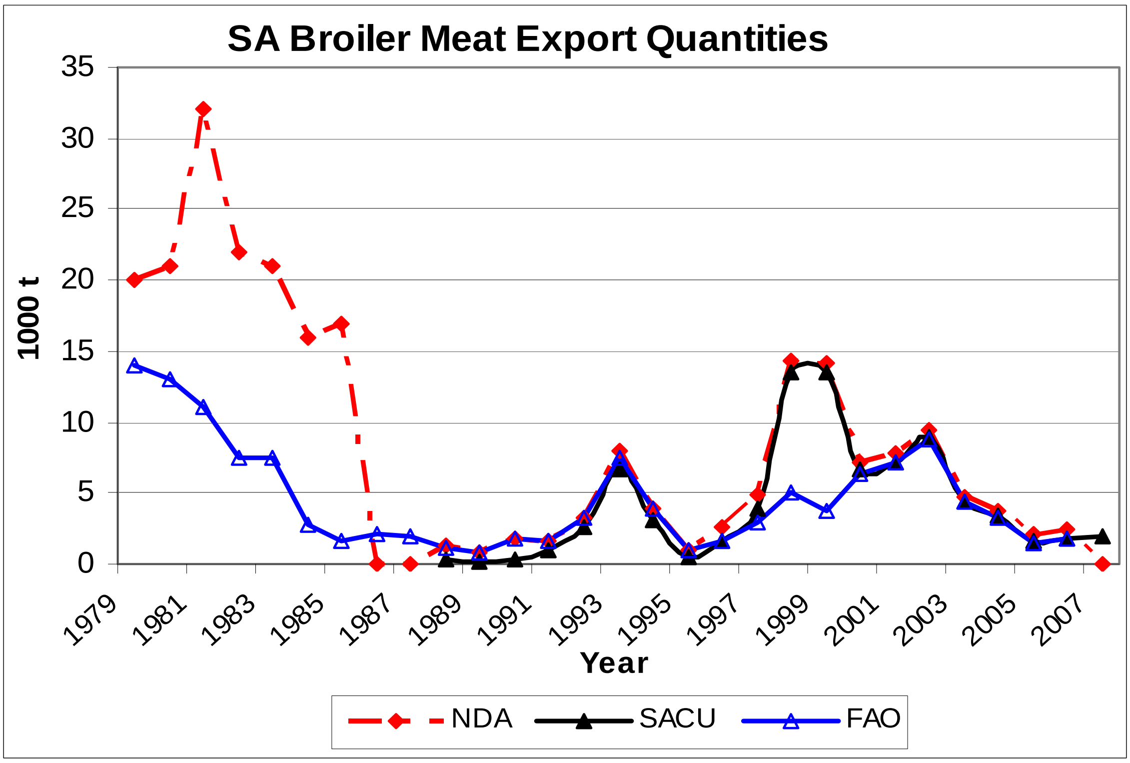

Figure 3.4: Total Annual Broiler Meat Exports
Source: NDA, 2009; SACU, 2009; FAOSTAT, 2009

Not enough observations were available to estimate a statistically significant annual domestic price equation. In order to include the impact of freight rates on import parity prices and also explicitly include different tariff lines, the possibility of estimating a quarterly domestic price equation was investigated for the period 1997-2004. There was however, a mis-match in terms of the data series available on a quarterly and annual basis, which resulted in a problem with taking the estimated elasticities from the quarterly equation to the annual version. As a result it was decided to estimate an annual equation based on a synthetic formulation of the missing freight rate data, extrapolating the freight rate data based on the percentage change in the US refiner acquisition price as obtained from Global Insight. The quarterly freight rate data was derived from a graph of eastbound US-Europe container freight rates, published by Ocean Shipping Consultants Ltd (2005), while tariffs for specific tariff lines were taken the USDA poultry attaché reports for SA.

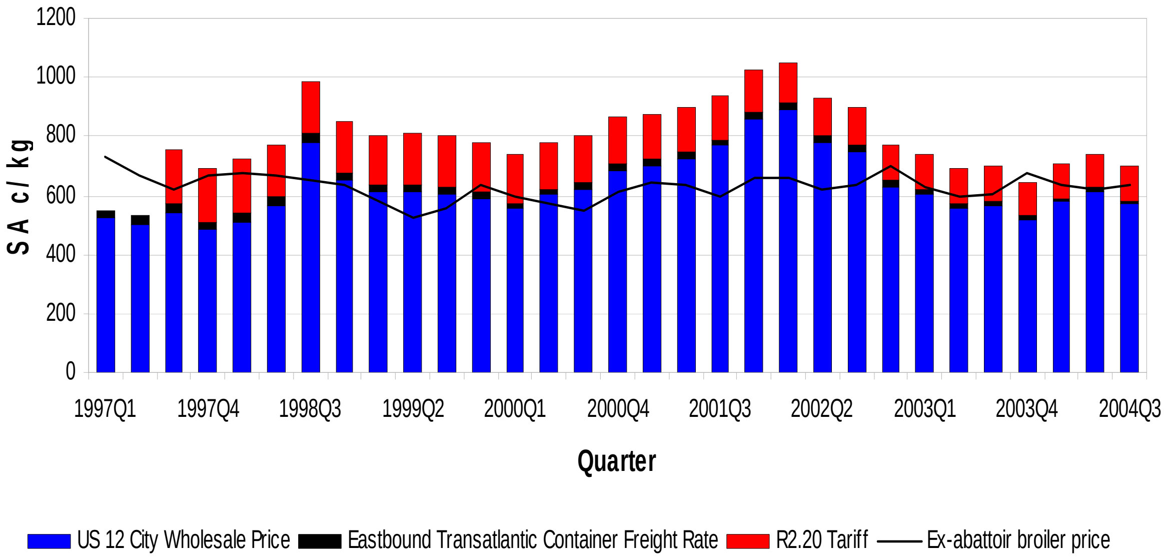

Figure 3.5: Real US Wholesale Import Parity and SA Ex-abattoir Prices
Sources: USDA, 2006, Ocean Shipping Consultants Ltd, 2005; Statistics South Africa, 2006; Reserve Bank, 2006; SAPA, 2006

All the annual macro-economic data such as the exchange rate, CPIF and GDP, as well as the data relating to other sub-sectors e.g. beef, pork and mutton, were taken from the Sector Model, with the exception of the Brazilian broiler export price, which was sourced from FAPRI, based on USDA poultry attaché reports for Brazil. All of the variables expressed in monetary terms were used after they were deflated using either the CPIF or the GDP deflator (GDPD). A list of the abbreviations for variable names, as found in the Sector Model and used in this text, is presented in Appendix A, while the data used in this study is presented in Appendix B.

3.4 ESTIMATION PROCEDURES AND STATISTICAL VALIDATION

In Sections 3.4.1 and 3.4.2 the estimation methods and the statistical tests used to evaluate the performance of the individual equations that make up the overall broiler model are described.

3.4.1 ESTIMATION PROCEDURES, MODEL SOLVING AND SIMULTION

In broad terms, the most frequently used econometric models used to study agricultural policy can be classified from a technical point of view as being either structural models based on a single equation, structural models based on multiple equations, or non-structural models (Sckokai, 2001). The Old and New Broiler Models are estimated as structural commodity models based on multiple individually estimated equations. Therefore the first step in the construction of the New Broiler Model was the identification of the individual equations and their appropriate specification based on economic theory and the availability of data as discussed in Section 3.3. This is true with the exception of imports, which were calculated as an identity because of the method used to close the model.

Structural models based on single or individual equations consist of a single variable being analysed by means of a linear/non-linear relationship (in this case a linear relationship) with a certain number of explanatory variables (Sckokai, 2001). The statistical formulation implies the addition of an error term/residual that represents the difference between the estimated values and the observed sample values of the dependent variable. Single equation models in agricultural policy analyses make use of classic econometric methods, starting from the ordinary least squares method and associated statistics (the R^2 for evaluating the goodness of fit, the *t* test for the significance of the parameters, and the *F* test for the tests on groups of parameters). This is the approach followed in estimating the individual equations making up the

New Broiler Model. This method may be generalised in the presence of serial correlation of the residuals (a typical problem of the use of time series) or heteroskedasticity (typical of the use of cross-sectional data). For the method of ordinary least squares to be applicable, the assumptions that the individual equations are linear in the parameters and that there is an absence of cross equation restrictions also need to hold. In practice, these assumptions rarely hold and the single equations may suffer from misspecifications (Sckokai, 2001; Conforti, 2001). These systems of equations are also normally estimated while simultaneously using ad hoc methods such as introducing parameters reported from previous studies. Where, parameters taken from the literature are, however, usually less accurate (Conforti, 2001). The use of these remedies can be seen in the final synthetic specification of the per capita consumption equation and the ex abattoir price.

Once the behavioural equations have been estimated or imposed, they were introduced into the BFAP Sector Model where they form part of a system of equations describing several of the larger agricultural industries that make up the Agricultural Sector. In this way the model is simulated/ solved in the form of a recursive system of equations. This is deemed appropriate due to the prevalence of the biological lag in agriculture (Ferris, 1998). Use is also made of a lagged specification of the production variable in the production equation as a proxy for capacity. The process of simulation can simply be referred to as the mathematical solution of a set of different equations (Meyer, 2006).

In the sections that detail the estimation results for the various equations, it should be kept in mind that one will typically find that some of the equations fit the data well, while others do not (Pindyck and Rubinfeld, 1998). As a result judgment has to be used when models are constructed regarding the overall statistical fit. It is also true that in practice it may be necessary to use specifications that are less desirable from a statistical point of view, but that improve the ability of the model to simulate well. Sckokai (2001) emphasized that in many econometric studies of agricultural policies, statistical model verification became less important than building a model coherent with the problem concerned.

3.4.2 STATISTICAL MODEL VALIDATION THEORY

Once the model has been solved, it will be used to make baseline and scenario projections and conduct policy analyses. Model validation procedures are used to critically examine its performance in reflecting the realities of the SA broiler industry. The procedures described by Pindyck and Rubinfeld (1998) as well as by Ferris (1998) were used as a basis.

The two most popular approaches used for model validation are (1) a more naïve ex post method of visual inspection using a graphical plot of the actual and simulated values, which should give a good indication of how well the historical simulation captures the turning points in the actual data for each of the endogenous variables, and (2) statistical measures for evaluating the goodness of fit (Pindyck and Rubinfeld, 1998).

There are two basic types of ex post simulations namely, static simulations and dynamic simulations (Pindyck and Rubinfeld, 1998). Static simulation is done using exogenous lagged dependent variables to generate the endogenous variables over the period of estimation. Dynamic simulations, on the other hand, use the solved values of the lagged endogenous variables to estimate the values of the dependent variables in the system. This implies that a dynamic simulation model "feeds" itself by generating estimates of the endogenous variables over the period of estimation (Calcaterra, 2002). These differences in simulation result in both methods yielding the same values for the endogenous variables in the ex post simulation period and different values in the ex post forecast period. The dynamic simulation process is regarded as being a more powerful simulation tool than the static simulation procedure (Meyer, 2002). Figure 3.6 shows the position of the ex post time horizon in relation to other periods that can be simulated.

Figure 3.6: Simulation Time Horizons
Source: Pindyck and Rubinfeld, 1998

In the context of this study, the validation statistics discussed below were thus applied to those values generated by the Old and the New Broiler Models using the dynamic simulation approach for the ex post simulation period. The calculated values for the models are discussed in Chapter 4, Section 4.2.

Below is a discussion of calculations, which were applied to measure the statistical validity of the New Broiler Model. The statistics below are specified, for illustrative purposes, for the endogenous SA broiler production variable (CKPRDSA) where:

$CKPRDSA_t^s$ = simulated value of $CKPRDSA_t$

$CKPRDSA_t^a$ = actual value pf $CKPRDSA_t$

t = number of periods in the simulation

The most commonly used statistic for evaluating model performance is the root-mean-square (RMSE) simulation error (Calcaterra, 2002). It measures the deviation of the simulated values from the corresponding observed values, with the magnitude of the error being evaluated by comparing the size of the error (difference) and the average value of the endogenous variable in question (Pindyck and Rubinfeld, 1998).

Equation 3.1: $RMSE = \sqrt{\frac{1}{T}\sum_{t=1}^{T}\left(CKPRDSA_t^s - CKPRDSA_t^a\right)^2}$

Although the evaluation of the errors can be understood in terms of average and absolute values, it is preferable to calculate the errors in terms of the percentage of the actual values. This is because, if the error is measured in percentage terms, the error measurements are more comparable over time for the same variable or among the endogenous variables in the model. Thus the RMSE simulation error statistic RMSE can be reformulated as the RMSE percent error (RMSE%[5]), which is defined as (Pindyck & Rubinfeld, 1998):

Equation 3.2: $RMSE\% = \sqrt{\frac{1}{T}\sum_{t=1}^{T}\left(\frac{CKPRDSA_t^S - CKPRDSA_t^a}{CKPRDSA_t^a}\right)^2}$

Other statistics include the mean simulation error (MSE), which is defined as

Equation 3.3: $MSE = \frac{1}{T}\sum_{t=1}^{T}\left(CKPRDSA_t^s - CKPRDSA_t^a\right)$

the MSE% (mean percentage error), which is defined as

Equation 3.4: $MSE\% = \frac{1}{T}\sum_{t=1}^{T}\left(\frac{CKPRDSA_t^s - CKPRDSA_t^a}{CKPRDSA_t^a}\right)$

as well as the MAPE (mean absolute percentage error), where the numerator is equal to the absolute value of the error terms.

Equation 3.5: $MAPE = \left[\frac{1}{T}\sum_{t=1}^{T}\frac{\left|CKPRDSA_t^s - CKPRDSA_t^a\right|}{CKPRDSA_t^a}\right]*100$

The following statistical tests, namely Theil's inequality coefficients, are variations of Equation 3.6, U (Ferris, 1998), where the comparison is strictly between forecasted and actual values for a given time period (t):

Equation 3.6: $U = \frac{\sqrt{\frac{1}{T}\sum_{t=1}^{T}\left(CKPRDSA_t^s - CKPRDSA_t^a\right)}}{\sqrt{\frac{1}{T}\sum_{t=1}^{T}\left(CKPRDSA_t^s\right)^2} + \sqrt{\frac{1}{T}\sum_{t=1}^{T}\left(CKPRDSA_t^a\right)^2}}$

The previous time period (t-1), is thus not taken into account in the measure U. The numerator of U is the root-mean-square (rms) simulation error, but the denominator is scaled in such a way that the value of U will always be between 0 and 1 (Pindyck and

[5] The syntax for RMSE% and the MSE% was taken from Meyer (2002).

Rubinfeld, 1998). This means that U=0 if there is a perfect fit over the period in question ($CKPRDSA_t^s = CKPRDSA_t^a$ for all t). The worst predictive performance is obtained when U=1. U can be decomposed and rewritten in the following forms, which indicate the relative proportions making up U.

Equation 3.7: $$U^M = \frac{\left(\overline{CKPRDSA}^s - \overline{CKPRDSA}^a\right)}{\frac{1}{T}\sum\left(CKPRDSA_t^s - CKPRDSA_t^a\right)^2}$$

Equation 3.8: $$U^S = \frac{\left(\sigma_s - \sigma_a\right)^2}{\frac{1}{T}\sum\left(CKPRDSA_t^s - CKPRDSA_t^a\right)^2}$$

Equation 3.9: $$U^C = \frac{2\left(1-\rho\right)\sigma_s\sigma_a}{\frac{1}{T}\sum\left(CKPRDSA_t^s - CKPRDSA_t^a\right)^2}$$

Where $\overline{CKPRDSA}^s$, $\overline{CKPRDSA}^a$, σ_s, σ_a are the means and the standard deviations of the series $CKPRDSA_t^s$ and $CKPRDSA_t^a$ respectively, and ρ is their correlation coefficient (adapted from Pindyck and Rubinfeld, 1998).

The proportions U^M, U^S and U^C are called the bias[6], variance and covariance proportions respectively (Pindyck and Rubinfeld, 1998). These three proportions of inequality provide a way to break down the simulation error into its characteristic sources.

U^M (bias proportion) provides an indication of the possible presence of systematic errors (Pindyck and Rubinfeld, 1998). If there is a large proportion of systematic bias present in the model, a revision of the model is recommended.

U^S (variance proportion) "indicates the ability of the model to replicate the degree of variability in the dependent variable" (Pindyck and Rubinfeld, 1998). This means that

[6] Where the bias error refers to either the under- or overestimation of the endogenous variables, resulting from the forecasting scheme (Ferris, 1998).

if the actual time series fluctuates considerably, while the simulated series shows little fluctuation, then U^S will be large, or vice versa.

U^C (covariance proportion) measures the unsystematic error, or the remaining error, after the deviations from the average values have been taken into consideration (Pindyck and Rubinfeld, 1998). A value of $U^C > 0$ is reasonable as predictions that are perfectly correlated with actual outcomes are not expected. For any value of $U^C > 0$, the ideal distribution of the inequality over the three sources is $U^M = U^S = 0$ and $U^C = 1$.

Another measure that is commonly used to evaluate a model's performance is the calculation of impact multipliers from a deterministic simulation (Calcaterra, 2002). Impact multipliers measure the changes in endogenous variables caused be changes in exogenous variables. The application of the Theil statistics described above can be found in Section 4.2, while the impact multipliers are recorded in Section. 4.5.

3.5 THE DEMAND SYSTEM

According to Ferris (1998), the "law of demand" states that the higher the price of a good, the lower the demand for that good (less will be purchased), where demand is the schedule of amounts that buyers will purchase given a set of prices (Marshall, 1920 as quoted by Ferris, 1998). This implies that the demand curve is downward sloping (Meyer, 2006). Consumer demand or retail demand can thus be seen as a schedule of quantities of a commodity in its final form that an individual consumer is willing and able to buy as the price of that commodity varies per unit time, ceteris paribus (Calcaterra, 2002). For broiler meat the end-products available to consumers have various amounts of value added processing resulting in a range of products from pre-cooked chicken pieces and frozen pre-made meals to whole fresh or chilled birds.

3.5.1 DEMAND THEORY

According to Varian (1987), the economic model of consumer choice is essentially based on the idea that "consumers choose the most preferred bundle from their budget sets" or, in other words, "consumers choose the best bundle of goods they can afford". Mathematically this model is an optimisation problem with the consumers' utility function, U(X), being maximised subject to the budget constraint, $I \leq X \cdot P$ (Varian, 1987 and Mas-Colell et al, 1995). Where I is the total available budget or level of income that an individual has, X is a vector of n commodities available for consumption and P is a vector of the corresponding prices for the n commodities. The assumption is that the consumer has a rational, continuous and locally non-satiated preference relation and U(X) is a continuous utility function that represents those preferences (Mas-Colell et al, 1995). It is thus assumed that the total budget is spent in the period that the consumer gains access to it, that is $I = X \cdot P$[7], and that the optimal choice resulting from solving this problem is homogenous of degree zero in prices and income (Varian, 1984).

As a result the consumer's problem can be restated as:

$$V(P,I) = \max U(X)$$

$$\text{Subject to } P \cdot X = I$$

The indirect utility function, represented as V(P,I), is thus used to provide the answer to the consumer's problem of maximizing utility at given levels of prices and income (Varian, 1984). The value of X that solves this problem is called the consumer's demanded bundle (X*), which expresses how much of each good the consumer desires at a given level of prices and income. The function that relates P and I to the demanded bundle is called the consumer's demand function, with the ordinary or Marshallian demand function being represented by X(P,I).

As is the case of production, the optimization behaviour can be characterised using calculus, and solved using the Lagrange multiplier. Where the Lagrangean expression is:

$$L(X, \lambda) = U(X) - \lambda\,(P \cdot X - I)$$

The first order conditions can be represented as $U(X^*)/dXi = \lambda P_i$, for I = 1,…., n, which can be re-arranged to give:

[7] I, P and X are also all assumed to be greater than zero, i.e. > 0.

For I ,j = 1,….,n (Varian, 1984)

When I is equal to the minimum income necessary to achieve the desired level of utility, given a set of prices P, the Hicksian demand function derived using the expenditure approach, is equal to the Marshallian demand function (Varian, 1984). This means that, given that I is equal to this level, any demanded bundle X*, can be expressed either as the solution to the utility maximization problem described above or by using an expenditure minimization approach.

The consumer demand for a commodity, as derived above, can thus be seen to be a function of prices (P) and income (I) in its simplest form, with the quantity demanded being written as $X^* = F(P_m, P_s, I)$ where P_m is the price of the commodity in question, and P_s is the price of competing and complementary goods (Calcaterra, 2002).

The neoclassical consumer's demand function described above, X(P,I), can be aggregated to represent the demand for a commodity by a set of consumers (Varian, 1984). In this study the population of SA is taken to represent the number of domestic broiler meat consumers. The aggregate demand function only inherits the properties of homogeneity and continuity from the individual demand functions (Varian, 1984).

Given the derivation of the demand function for a particular good, both for the individual consumer and for a particular market, it is often of interest to measure how "responsive" demand is to a change in price or income (Varian, 1987). In order to do this, economists have chosen to use the measure known as elasticities, where one of the main appeals is that the measure is defined so that it is free of units specific to the underlying variables, thus facilitating the comparison of variable behaviour. In this study there are three main elasticities that are of interest on the demand side, namely the own-price elasticity of demand, the cross-price elasticity of demand and the elasticity of income.

The price elasticity of demand, e, is defined as the percentage change in quantity divided by a percentage change in price (Varian, 1987) of that good, ceteris paribus

(Calcaterra, 2002). If Xi represents a demand curve and P_i represents the price, the own price elasticity of demand is defined as:

$$e_{ii} = \frac{\partial X_i}{\partial P_i} \cdot \frac{P_i}{X_i}$$ (Sadoulet and de Janvry, 1995)

Price elasticities are usually negative as demand is expected to decrease when price increases (Sadoulet and de Janvry, 1995). If the absolute value of the elasticity, e_{ii} , is greater than 1, the curve is called elastic. If the absolute value is, however, between 0 and 1, then the curve is called inelastic. If e_{ii} is inelastic, an increase in price induces an increase in expenditure despite a decrease in demand, because the change in quantity is smaller than the change in the price. If, e_{ii} is elastic, however, expenditure decreases with a price increase as the decline in demand is larger than the price increase. It is also interesting to note that if the elasticity of demand is calculated for a very short time-period e.g. a quarter or one month, it is likely to be different to an elasticity that is measured over a longer time period, e.g. one year (Hancock et el., 1984).

The cross price elasticity of demand for good Xi is estimated as a function of a change in the quantity demanded of good Xi, given a change on the price of good Xj, ceteris paribus (Calcaterra, 2002):

$$e_{ij} = \frac{\partial X_i}{\partial P_j} \cdot \frac{P_j}{X_i}$$ (Sadoulet and de Janvry, 1995)

Where if $e_{ij} > 0$, i and j are considered gross substitutes, and if $e_{ij} < 0$, I and j are considered gross complements (Sadoulet and de Janvry, 1995).

In a similar fashion, the income elasticity of demand measures the proportionate change in the demand of a good "i" due to a percent change in income (Calcaterra, 2002). The income elasticity of good X_i is mathematically represented as :

$$\eta_i = \frac{\partial X_i}{\partial I} \frac{I}{X_i}$$ (Sadoulet and de Janvry, 1995)

This means that if η_i > 1, then demand increases more than proportionally to income, and hence the expenditure share of this good increases as income increases, where as if η_i < 1, the expenditure share of this good declines as income increases. The latter generally being the case for food consumption (Sadoulet and de Janvry, 1995). Caution should be exercised in the interpretation of the income elasticity as the elasticities from time series include dynamic effects such as changes in income distribution, urbanisation and the structure of population over time.

3.5.2 CONSUMPTION EQUATIONS

For the purpose of this study, no documentation describing a stand alone model for the SA broiler industry was allocated. Most of the available models that include some descriptions relevant to the SA broiler industry were built using the Almost Ideal Demand System (AIDS) in which beef, chicken, pork and mutton are generally modelled together. Table 3.1 lists some of the variables that were used in these studies to estimate the demand for chicken meat and also in other studies that included broilers such as those discussed in McGuigan and Nieuwoudt (2002). Some variables were not incorporated in the table as they were specifically created for a particular type of model being estimated, e.g. the budget (expenditure) share of a particular good included in a Linear Approximated Almost Ideal Demand System (LA/AIDS) such as that estimated by Calcaterra and Kirsten (2003) as well as Taljaard et. al (2004).

Table 3.1: A Selection of Factors previously used to estimate Broiler Demand

Explanatory Variable	Used in
Real weighted average retail prices	Uys (1986)
Deflated Annual Per Capita Income	Uys (1986)
Population Growth	Nieuwoudt (1998a, 1998b), McGuigan and Nieuwoudt (2002)
Urbanisation	Nieuwoudt (1998a, 1998b), McGuigan and Nieuwoudt (2002)
Income Per Capita Growth	Nieuwoudt (1998a, 1998b), McGuigan and Nieuwoudt (2002)
Nominal Price of Substitutes	Taljaard et. al. (2004)[8]

As indicated in Table 3.1, population is normally incorporated in time series analysis by converting consumption and income to a per-capita basis. The rationale is that year-to-year changes in population are usually accompanied by one-to-one changes in total consumption and that dividing consumption or consumer income by population implicitly captures this relationship (Ferris, 1998). This specification saves degrees of freedom when using ordinary least squares (OLS) analysis. It also helps to avoid the problem of multicolinearity, which tends to arise when incorporating population as an individual variable, as a country's population is generally expected to monotonically (without reversal) increase resulting in it being strongly correlated with other time series.

In the specific case of SA, Uys (1986) and Nieuwoudt (1998a) noted that the factors used to estimate demand for various livestock products differed significantly amongst the different population groups. Nieuwoudt (1998a) ascribed these differences in consumption to the differences in living standards and taste preferences. It was also noted that these differences in consumption were expected to lessen and eventually merge. The implication of this being that the applicable explanatory variables chosen at the national level could be expected to be more representative and as such more statistical significant in explaining the movements in the dependent variables.

The applicability of historic data in explaining the behaviour of the dependent variable(s) may vary due to several factors, one of them being the possibility of future shifts in consumption preferences. Kostov and Lingard (2004), for instance, found

[8] Taljaard et al. (2004) estimated a Linear Approximated Almost Ideal Demand System

evidence of shifts in the long-term equilibrium of the meat consumption system in the UK after the BSE scare in beef. As the exact timing of future regime changes cannot be predicted, the long-run equilibrium could be subject to a kind of path dependency and, although this may seem to contradict the conventional view of equilibrium, it does in fact present a more realistic view of economic processes (Kostov and Lingard, 2004).

In this study whole-bird ex abattoir prices are used in the consumption equation, which are reported at wholesale level. Ferris (1998), noted that farm or wholesale prices can be used if (1) retail prices are unavailable; (2) measurement errors are large for retail prices relative to farm or wholesale prices (which is apparently quite common); (3) the product cannot be readily identified at retail, and (4) the margin of between farm or wholesaler and retail prices is quite small. Although data on retail level is available, the margins between wholesale - and retail prices are relatively small and constant (Figure 2.19) and therefore, the ex-abattoir prices where selected to drive local demand and supply.

In previous studies that included the SA broiler market, various own price elasticities were calculated. Some of these elasticities were calculated as partial (uncompensated) own price elasticities, while the majority were calculated as total own price elastiticities (compensated). The partial and total own price elasticities are expected to differ for the SA broiler industry as SA meat products have close substitutes (Nieuwoudt, 1998b). A summary of identified own price elasticities is presented in Table 3.2 below.

Table 3.2: Partial and Total Own Price Elasticities of Demand for Poultry Meat

Partial Elasticities	Total Elasticities	Source
–1.66		Hancock et. al. (1984) [estimated for the period 1962-1981]
–0.36		Badurally Adam and Darrach (1997) [estimated for the period 1971-1995]
	–1.477	Uys (1986) [estimated for the period 1956-1970]
	–1.588	Uys (1986) [estimated for the period 1970-1981]
	–1.46	Uys (1986) [reported that Hancock estimated an own price elasticity for the period 1956-1981]
	-0.193	Taljaard et.al. (2004) [compensated elasticity (1970 –2000)]
-0.35		Taljaard et.al. (2004) [uncompensated elasticity (1970-2000)]

Just as the own price elasticites are important in validating the estimation results of this study, so are the cross price elasticities. Table 3.3 presents a summary of some of the identified cross price elasticties from previous studies that included broiler meat.

Table 3.3: Cross Price Elasticities for Chicken Meat

Beef	Mutton	Pork	Source
-0.62	1.26	0.98	Hancock et. al. (1984) [1962-1981]
0.455	0.188	-0.340	Uys (1986) [1956-1970]
0.556	0.068	-0.092	Uys (1986) [1970-1981]
0.43	-0.02	-0.04	Badurally Adam and Darrach (1997) [conditional slutsky elasticity 1971-1995]
0.139	0.094	-0.039	Taljaard et. al. (2004) [compensated elasticities 1970-2000]
-0.11	0.009	-0.074	Taljaard et. al. (2004) [uncompensated elasticities 1970-2000]

The cross-price elasticities in the Table 3.3 above, can, for example, be interpreted as follows: a 1% fall in the price of beef will result in chicken consumption falling by 0.43% (Badurally Adam and Darrach, 1997). Table 3.3 also clearly shows that a variety of estimated results have been published in which cross price elasticities for traditionally accepted meat substitutes range from (+) to (-) values indicating that some of these substitutes (denoted by positive values) have also been recorded as having negative values, which are associated with complements. This is contrary to a priori expectations based on the categorisation of meat from livestock as being substitutes. These studies have not recorded an underlying reason in the behaviour of these industries that can explain the occurrence of negative cross-price elasticities. Where suggestions have been made in an attempt to explain the negative values, the suggestions have been kept to possible distortions due to the method used.

3.5.3 THE SA BROILER MEAT CONSUMPTION EQUATION

Essentially the Consumption Equation is based on the general economic specification, $Q^D=F(P_m,P_s,I)$[9], described in Section 3.5.1. Per capita consumption is used as the dependent variable (Q^D) and is calculated as the kg of broiler meat consumed per capita on an annual basis. The variable representing the own price of broiler meat (P_m) is specified as the real ex abattoir price of broiler meat (RCKPPSA in cent/kg). (P_s) represents the prices of substitutes and complements and (I) the disposable income. As previously discussed, the use of the ex abattoir broiler price is appropriate in this equation as there is a lack of retail price data, there is a fairly constant margin between producer prices and retail prices, and there is a possibility of encountering identification problems at the retail level (Section 3.5.2 in Chapter 3).

Based on previous studies (e.g. Hancock et al., 1984 and Taljaard et al., 2004), the real carcass prices of other animal protein sources, namely mutton, beef and pork, should be included in the model. Figure 2.19 in Chapter 2 illustrated the interrelated movements of these animal protein prices. Due to multicollinearity concerns arising because of these interrelated movements, an index (MBFP index) was constructed to

[9] The sum of individual demand curves is assumed to equal total consumer demand.

capture the sum of the cross commodity effects in this study. The index is specified as the sum of the ratios of the real carcass prices (cent/kg) over their respective national annual levels of production in 1000t. The consumer price index for food in metropolitan areas is used to deflate nominal prices to real values. Real per capita gross domestic product (RGDP), in turn, is used as a proxy for disposable income (I). The RGDP variable is specified in natural logarithmic form in order to ensure that the income elasticity falls as income rises. There is a possibility of strong growth in future income as suggested by the emergence of the "Black Diamonds" discussed in Chapter 2. Hence, the logarithmic specification is used to try and keep the impact of the projected consumption levels from reaching unrealistic levels. This is similar to the income specification used by Fuller (1997) to model the demand for egg consumption in China (see Section 3.5.2). Equation 3.10 presents the estimated consumption equation for broiler meat in South Africa.

Equation 3.10: CKPCCSA = f (RCKPPSA, MBFP Index, ln(RPCGDP))

Table 3.4: Estimation Results for the SA Broiler Per Capita Consumption Equation

Explanatory Variable	Parameter Estimate	T-Statistic	P-Value	Elasticity at the Mean
Intercept	-368.364	-5.982	0.000	
RCKPPSA	-0.018	-10.842	0.000	-0.768
MBFP Index	0.186	1.121	0.273	0.144
ln(RPCGDP)	41.661	6.358	0.000	2.114
DUM81	-3.514	-2.118	0.045	-0.006

F-Test	52.252	**p-value**	0.000	R^2	0.897	**Durbin – Watson**	1.396

The results for Equation 3.10 given in Table 3.4 indicate that the individual T-statistics are all significant at the 5% level, as is the overall equation according to the F-statistic. The R^2 value also indicates a good fit at a value over 0.8 and the Durban-Watson Statistic indicates that there is probably no problem with serial correlation in this specification. However, having a closer look at the elasticities, the income elasticity seems very high at 2.11, especially given the fact that chicken meat is the cheapest type of meat. Despite of the logarithmic specification the large elasticity resulted in unrealistic high projected consumption levels when this equation was tested in the BFAP sector model. Hence, synthetic adjustments were made to the estimated equation to lower the income elasticity. The final per capita consumption equation in the New Broiler Model is specified as follows:

Table 3.5: Synthetic SA Broiler Per Capita Consumption Equation used in New Broiler Model

Explanatory Variable	Parameter Estimate	Elasticity at the Mean[10]
Intercept	-41.364	
RCKPPSA	-0.018	-0.37
MBFP Index	0.186	0.10
ln(RPCGDP)	8.261	0.26
DUM81	-3.514	0.000

The only parameters that differ between the estimated and the synthetic equation are the intercept and Ln(RPCGDP). The intercept term was adjusted in order to compensate for the level change resulting from the changed Ln(RPCGDP) coefficient. Total domestic consumption was then obtained through multiplying the estimated per capita consumption values by, POP, the number of people in the population (in millions).

It is interesting to note that the per capita consumption equation in the Old Broiler Model was specified as follows:

Table 3.6: Estimation Results for the Old SA Broiler Consumption Equation

Explanatory Variable	Parameter Estimate	Elasticity at the Mean[11]
Intercept	12	
RBFAPSA	0.005	0.1641
RCKPPSA	-0.01	-0.3012
RPOPSA	0.001	0.0249
RPCGDP	0.0009	0.5796

With: RBFAPSA – Real Beef Auction Price, South Africa
RCKPPSA – Real Chicken ex-abattoir Price, South Africa
RPOPSA – Real Pork Auction Price, South Africa
RPCGDP – Real GDP per capita

[10] These elasticities are calculated for the 15 year period between 1992 and 2007.
[11] These elasticities are calculated for the 15 year period between 1992 and 2007.

In the Old Broiler Model the overall per capita demand for broiler meat was driven by real per capita GDP, own price and substitute prices, each of which had the expected sign based on economic theory. This equation was synthetically constructed right from the beginning and no attempt was made to find a statistically sound equation.

It is unfortunate that, despite of going to great lengths to find a statistically sound equation to estimate domestic per capita consumption with the appropriate variables, the equation with the best statistical fit was found to be unsuitable from an economic perspective. Hence, apart from the fact that the per capita consumption equation in the New Broiler Model complies with the homogeneity condition whereas the equation in the Old Broiler Model does not, there are no apparent benefits of the new equations at this stage. Once the scenario analysis is performed in the next chapter, the economic response of the new equation will be illustrated within the BFAP sector model.

3.6 THE SUPPLY SYSTEM

Supply is typically seen to consist of domestic production, inventory or stocks and imports. Farm supply is seen to be the schedule of amounts that farmers are willing to produce at different expected price levels, *ceteris paribus* (Ferris, 1998). In the case of the SA broiler industry the capacity for keeping stocks is so low and the data so scarce that they are typically taken as being zero (USDA, 1995a; USDA, 1995b; USDA, 1996; USDA, 1997a; USDA, 1997b; USDA, 1998). As a result no broiler meat inventory equation was estimated in this study and therefore inventory theory is not dealt with in this section.

3.6.1 PRODUCER SUPPLY THEORY

This section is based on the neo-classical theory of the firm, where the assumption is that producers maximize their profit or net returns subject to some technical and institutional constraints (Calcaterra, 2002). The technical constraints referred to here are the relationships between the physical factor inputs and the maximum output level for the given technology per unit time, which define the firm's production function.

Institutional constraints in turn refer to the market structure, which determine the economic environment in which firms operate.

One of the simplest ways to illustrate the physical relationship between physical output and factor inputs, is to consider a farm that uses land –L; labour –W, and other inputs such as feed and capital –K, in the production of a specific commodity –Q (Calcaterra, 2002; Meyer, 2006). The expected production function, which is simply a representation of the technical relationship between inputs being used and output, can be written as Q= F(L,W,K), where $\frac{\partial F}{\partial L} \geq 0$, $\frac{\partial F}{\partial W} \geq 0$, $\frac{\partial F}{\partial K} \geq 0$. (These factor inputs are assumed to have a non-negative marginal contribution to production/ output, i.e. quasi-rents are not negative). The second derivatives are also assumed to be greater than zero for the admissible production technology structures. This means that the law of diminishing marginal return is imposed, which ensures that the production function is not concave to the origin. Let p denote the expected price of Q, l the rental cost for land L, w the cost of labour W and k the cost of other inputs K. The theory also assumes that the level of production (output level) and output prices are independently distributed random variables and that the farmer is risk neutral. The farmer's decision problem is to maximize profit: $Max\Pi$(p,l,w,k,TFC) = Max{pQ-lL-wW-kK-TFC}, where pQ is the expected revenue, lL is the cost of land, wW is the cost of labour, kK is the cost of capital and other inputs and TFC is the total fixed cost. Either the profit maximisation or cost minimisation approach can now be used to derive the output supply response from the profit function by means of the first order conditions. The first order conditions of profit maximization can be written as follows:

$$p\frac{\partial Q}{\partial L} - l = 0,\ p\frac{\partial Q}{\partial K} - k = 0,\ p\frac{\partial Q}{\partial W} - w = 0$$

According to these three equalities, the farmer will maximize profit by producing at output levels where the expected value of the marginal product of each input is equal to the inputs cost (Calcaterra, 2002). The second order conditions that are derived from the above first order conditions, require concavity of the production function, which ensures convexity of the profit function to input and output prices. Assuming that the production function is invertible, the optimum input demand can be expressed as a function of input and output prices, $L^{\alpha}(p,l,w,k)$, $W^{\alpha}(p,l,w,k)$ and $K^{\alpha}(p,l,w,k)$. These input demand functions are homogenous of degree zero in the input and output prices. The output supply function is then obtained through substituting the input demand functions into the production function. The derived output supply function is then $Q^{\alpha} = f(L^{\alpha}, W^{\alpha}, K^{\alpha})$, which is also homogenous of degree zero in output and input prices.

The supply function is expected to be upward sloping and the input demand functions are downward sloping, given the convexity property of the profit function (Calcaterra, 2002). It also follows that the marginal effects of an increase in output price(s), p, on input demands are equal in absolute magnitude, but are opposite in sign, to the marginal effect of an increase in the corresponding input prices on the magnitude of output supply.

Elasticities, are a convenient way of expressing relationships within the supply system, measuring the degree of responsiveness of the independent variable to a percentage change in the dependent variables (Calcaterra, 2002). As mentioned above, there are generally four types of elasticities that are considered as being important in econometric studies, namely: own price elasticity, cross price elasticity, input elasticity, and income elasticities. An elasticity is defined as the percentage change in a dependent variable due to the percentage change in a dependent variable (Sadoulet and de Janvry, 1995). If Xi represents a supply curve and P_i represents the price of good Xi, the own price elasticity of demand is defined as:

$$e_{ii} = \frac{\partial X_i}{\partial P_i} \cdot \frac{P_i}{X_i}$$ (Sadoulet and de Janvry, 1995)

The own price elasticity of supply measures the percentage change in output (Xi) in response to a 1% change in the output price (Pi), *ceteris paribus* (Calcaterra, 2002).

If it is assumed that a producer can only produce two commodities (i and j), then the cross price supply measures the percentage change in output (i) caused by a 1%

change in the price (j) of another output. The mathematical representation of the elasticity will then be as follows: $e_{ij} = \frac{\partial Xi}{\partial P_j} \cdot \frac{P_j}{X_i}$.

3.6.2 PRODUCTION EQUATIONS

According to Nieuwoudt (1998b), less is known about supply shifts than demand shifts. The former depend upon technological changes in production and changes in feed costs. These are seen to be less predictable than factors influencing demand shifts, such as population growth, which often have indirect or varied impacts on the supply function. The perceived difficulty in predicting supply responses may explain the lack of supply models for estimating components of the livestock/meat sector in SA.

Buhr (1993) noted that although supply dynamics have received considerable attention in agricultural economics, the attempts to model the supply behaviour of the livestock industry have generally been a mixture of economic theory and ad hoc techniques.

If one looks at the fundamentals of supply dynamics, then the following characteristics are generally highlighted: (1) the biological delays and cycles inherent in production and (2) the decision to produce is based on certain expectations, notably expected prices at the time of sale/harvest (Buhr, 1993; Calcaterra, 2002; Meyer, 2006). The most cited types of expectation in the literature are, according to Calcaterra (2002), naive, extrapolative, adaptive, rational and quasi-rational, and the most widely used is the adaptive expectations assumption.

In modelling supply responses the time variable may be introduced explicitly using several approaches (Meyer, 2006). The most common approaches are the partial adjustment approach and the adaptive expectations approach. The underlying assumption of the partial adjustment approach is that movements from the current demand and supply levels to a new equilibrium level, due to changes in economic and/or technical conditions, may not be immediate. The underlying assumption of the adaptive expectations approach is that agricultural producers base their decisions on certain expectations regarding the future values of relevant prices.

The Nerlove model is a combination of the partial adjustment model and adaptive expectations model (Meyer, 2006), with the Koyck transformation being used to obtain the final version of the equation. The general Nerlovian supply response model can be specified as:

Equation 3.11: $q_t^d = \alpha_1 + \alpha_2 p_t^e + \alpha_3 z_t + u_t$ (Sadoulet and de Janvry, 1995)

In equation 3.11, q_t^d is the desired level of production in the current time period t; p_t^e is the expected price or, more generally, a vector of relative prices including the prices of the output(s) itself as well as the prices of competing products and factor prices, with one of these prices chosen as the numeraire); z_t is a set of exogenous factors such as weather variables; u_t accounts for the unobserved random factors affecting the level(s) of production and has an expected value of zero; and the α_i's are coefficients (Sadoulet and de Janvry, 1995).

Due to the fact that full adjustment to the desired level of production may not be possible in the short run, the actual adjustment in area will only be a fraction δ of the desired adjustment:

Equation 3.12: $q_t - q_{t-1} = \delta(q_t^d - q_{t-1}) + v_t$ where $0 \leq \delta \leq 1$,

where q_t is the actual production, δ the partial-adjustment coefficient, and v_t represents a random term with zero expected value.

The price that the decision maker expects to prevail at slaughtering cannot be observed (Sadoulet and de Janvry, 1995). Therefore, one has to specify a model that explains how the agent forms expectations based on actual and past prices as well as other observable variables. For farmers, an example of a formulation that represents a learning process could potentially be the adjustment of their expectations as a fraction γ of the magnitude of the mistake they made in the previous period, that is, the difference between the actual price and expected price in t-1:

Equation 3.13: $p_t^e - p_{t-1}^e = \gamma(p_{t-1} - p_{t-1}^e) + w_t$, $0 \leq \gamma \leq 1$, or

Equation 3.14: $p_t^e = \gamma p_{t-1} + (1-\gamma)p_{t-1}^e) + w_t$,

where, according to Sadoulet and de Janvry's (1995) formulation, p_{t-1} is the price that prevails when decision-making for production in time period t occurs, γ is the adaptive-expectations coefficient, and w_t is a random term with zero expected value.

As p_t^e and q_t^d are not observable, we eliminate them from equations 3.2, 3.3, and 3.4. Substitution from equations 3.12 and 3.14 into equation 3.13 and rearrangement give the reduced form:

Equation 3.15: $q_t = \pi_1 + \pi_2 p_{t-1} + \pi_3 q_{t-1} + \pi_4 q_{t-2} + \pi_5 z_t + \pi_6 z_{t-1} + e_t$

Equation 3.15 is the form of the supply response model defined by equations 3.2, 3.13, and 3.14 (Sadoulet and de Janvry, 1995), that can be estimated. It is however, over-identified, since there are six reduced-form coefficients π but only five structural parameters (α_1, α_2,, α_3, γ and δ). To obtain a unique solution for the latter, a nonlinear constraint must be imposed on the parameters of the reduced form. The Nerlove model thus leads to exactly the same reduced form equation as the adaptive expectations model, except that it does not induce additional serial correlation in the disturbances if there was none to start with (Buhr 1993).

According to Buhr (1993), explicit incorporation of biological structure into a model of the livestock sector was first done by Chavas and Johnson in 1982, when estimating broiler supply response. He argues that the biological lags inherent in the production of livestock offer prior information on the production process, which should be used to advantage. When taking this factor into account, however, it is important to note that there may be a split in terms of the different types of production units, e.g. there may be mix of small production units raising livestock for personal consumption (backyard producers), small producers specializing in meat production (specialized households), and large state-run or commercial farms (intensive producers) (Fuller, 1997). These different production units may exhibit a great deal of variation in production methods, as well as productivity and output quality. Ideally a model would explicitly take into account the different major production technologies and their weight in terms of volume produced, as in the case of Fuller's (1997) representation of the Chinese livestock industry. At present, however, there is not enough data available in SA about the cost structure and actual output levels of specialised households and backyard production to adequately specify separate production functions. Therefore, the model developed in this study characterises the broiler industry as an aggregate technology.

Another aspect, which has received insufficient attention, is the form in which price variables enter supply equations (Buhr, 1993). Many researchers have incorporated the output price and the most relevant input price in their analysis either independently or as a ratio of output price to input price ratio, but that this does not allow a response to alternative feed prices. In this study, as in Buhr's, a feed cost index will be used in a price ratio format similar to that used in previous studies, which will allow for improved response to feed cost changes.

3.6.3 THE SA BROILER MEAT PRODUCTION EQUATION

In both the Old as well as the New Broiler Model a set of inclusion rates was used to build a feed cost index. This index was then used in the calculation of the production cost index, where the other costs in production are represented by a proxy variable, namely the gross domestic production deflator (GDPD). It is important to note that this index is not an estimated equation, but is simply constructed to present a true reflection of actual production costs in the broiler industry. In the Old Broiler Model 32% of the cost of production to the end of the slaughtering process was attributed to the GDPD, while in the new model 45% is attributed to costs other than feed. This change is based on information obtained from the industry (Coetzee, 2006; Dunn, 2006; Kupka, 2004).

Table 3.7: Comparison of Inclusion Rates used in the Old and New Broiler Model

Broiler Feed Ingredients	Abbreviation	Inclusion Rate	Inclusion Rate	Real Price
		Old Broiler Model	New Broiler Model	New Broiler Model
Maize[1]	CKFMIC	0.650	0.65	
Wheat	CKFWHIC	0.010	-	
Sorghum	CKFSGIC	0.005	-	
Sunflower cake	CKFSCIC	0.020	0.03	
Soybean cake	CKFSBCIC	0.130	0.18	
Soybean full fat[2]	CKFSBIC	0.040	0.05	
Fishmeal	CKFFMIC	0.025	0.025	
Vegetable oil			0.023	133.4[3]
Vitamin/mineral pack			0.005	48[3]
Synthetic lysine			0.003	37.5[3]
Synthetic methionine			0.003	67.5[3]
Other (Enzymes, etc)			0.001	50[3]
Limestone			0.01	3.2[4]
MCP			0.015	42.75[4]
Salt			0.005	2.9[4]
Total		**0.880**	**1.000**	

[1] Minimum of white and yellow maize price is taken
[2] The soybean producer price is used here
[3] These nominal prices for 2006 are projected back to 1979 and forward to 2015 using the annual % change in the Rand/US$ exchange rate (EXCH).
[4] These nominal prices are projected back to 1979 and forward to 2015 using the annual % change in the GDPD

Source: Dunn, 2006

Table 3.7 shows the inclusion indices that are used in the previous as well as in the new version. Apart from the difference in the inclusion rates, the new feed cost index also incorporates more specific ingredients in order to construct a more refined feed cost index. Taking this new information into account, the chicken input price index for SA (CKIPISA) is constructed where the broiler feed ingredients have a weighting of 55% and the GDPD has a weighting of 45%.

The weighted average contributions of vegetable oil, vitamin/mineral pack, synthetic lysine, synthetic methionine and other feed supplements such as enzymes can be grouped together because, due to a lack of data, their values are all extrapolated using the percentage change in the R/US$ exchange rate from base values from 2006, as obtained from Dunn (2006). This assumption is also used to project these values to the year 2015. The weighted average contributions of lime, MCP and salt can also be grouped together and extrapolated based on the fact that they are assumed to move in direct proportion to the GDPD (Dunn, 2006).

The main difference between the input cost indices of the Old and New Broiler Model is that the input cost index of the Old Broiler Model included wheat and sorghum as feed ingredients, and the new one does not. The new input cost index, on the other hand, includes additional nutritional components (ingredients) including vegetable oil and minerals that are highly correlated with the exchange rate. Because of these differences the new input cost index may be more sensitive to the exchange rate than the old one.

The newly constructed CKIPISA variable is introduced into the system of equations through its inclusion as an exogenous variable in the production equation (CKPRDSA). Production is expected to be negatively related to CKIPISA and positively related to the ex abattoir broiler price (CKPPSA).

Lagged production (LCKPDRSA) is included in the production equation to take account of the 18 month lead time, asset specific nature of investment and the level of production (flock data was unavailable). It is also important to note that producers are assumed to continue with production in the short term if the revenue generated through sales is greater or equal to the fixed costs incurred by the firm, e.g. in periods of the year when demand is not high like it is around Christmas. The amount produced in the current period is so strongly correlated with the previous period, in large part due to the strong upward trend that characterises this time series, that LCKPRDSA is specified in logarithmic form, thus ensuring that its elasticity declines as the overall level of production increases (in a similar fashion to the specification of the CKPCCSA (Section 3.5.3) and Fuller (1997)).

The possibility of introducing the production variable (CKPRDSA) lagged by two years, i.e. q_{t-2}, into the equation was tested, but found to be insignificant at the 10% level. This is in line with expectations based on the fact that part of the decision how to utilise the current available capacity takes place at time t, while the majority of the decisions around expansion of production take place at t-1. No exogenous factors such as temperature were included in the equation specification. The resulting form of Equation 3.15 that was originally estimated in this study could thus be represented as $q_t = \pi_1 + \pi_2 p_{t-1} + \pi_3 q_{t-1} + e_t$, where the vector of relative prices p_{t-1} was split into the own price (CKPPSA) and input costs as represented in the chicken input price index (CKIPISA). Both CKPPSA and CKIPISA were introduced into the equation in their real form after being deflated using the consumer price index for food (CPIF).

This equation did not catch turning points well, as the estimated equation was driven by production in the previous period. This was mainly due to the sensitivity of the estimated equation caused by the strong trend component in the production time series. In order to resolve this problem two steps were taken, namely (1) the LCKPRDSA was combined with a technical production indicator, which can also be seen as a measure of competitiveness, namely the number of production cycles per annum (365/CKDAYSSA) and (2) this combined variable was introduced as a function of a natural logarithm in order to reduce the sensitivity of the equation to these values and to allow a greater ability to respond to the relationship between CKIPISA and RCKPPSA in the time period t. The days in the SA production cycle (CKDAYSSA) can be seen as an indicator of how stock turnover has improved over the period. In the equation this indicator is expressed as the number of cycles per annum and is based on a trend calculated on data points for 1992-2004 (Figure 2.12), as data for the entire period was not available.

Equation 3.16: CKPRDSA = f (RCKPPSA, RCKIPISA, LCKPRDSA*365 / CKDAYSSA)

Table 3.8: Estimation Results for the SA Broiler Production Equation

Explanatory Variable	Parameter Estimate	T-Statistic	P-Value	Elasticity at the Mean
Intercept	-5261.699	-8.616	0.00	
RCKPPSA	0.285	1.944	0.063	0.19
RCKIPISA	-0.168	-0.234	0.817	-0.05
Ln(LCKPRDSA*Cycles)	670.070	11.042	0.000	0.62

F-Test 191.869 **p-value** 0.000 **R^2** 0.958 **Runs Test Mean**[12] 7.75

[12] As the estimated equation for CKPRDSA includes a lagged endogenous variable, the Dubin Watsin statistics cannot be used to test for autocorrelation (Gujarati, 1998). The Runs or Geary test has thus been used in its place.

The individual parameter value for the lagged logarithmic production multiplied by the number of production cycles in the previous production year (based on a trend estimated on data derived from Figure 2.12) is statistically significant at the 1% level, while the parameter estimate for the real ex abattoir price (RCKPPSA) is statistically significant at the 10% level. The real broiler input cost index (RCKIPISA) variable is not statistically significant at the 5-10% level, but is kept in the equation because of its economic significance and the resulting increase in sensitivity to changes in production costs that both the literature and industry information indicate to be relevant.

The overall equation is also highly statistically significant according to the F-Statistic and R^2. The R^2 value is so high that it indicates potential multicollinearity and / serial correlation within the equation. The Runs Test indicates that the null hypothesis of random residuals cannot be rejected at the 5% level of statistical significance, indicating that serial autocorrelation does not appear to be a problem for the CKPRDSA equation. Unlike the changes that had to be made to the per capita consumption equation, the production equation performed well when it was introduced in the BFAP sector model and no further synthetic adjustments were made to the equation. The economic performance of the equation within the context of the BFAP sector model is illustrated in Chapter 4.

In order to make a comparison, the production equation of the Old Broiler Model is specified as follows:

Table 3.9: Old SA Broiler Production Equation

Explanatory Variable	Parameter Estimate	Elasticity at the Mean[13]
Intercept	190	
LAG (CKPRDSA)	0.6	0.5329
CKPPSA/CKIPISA	45.165	0.2717

Note: The coding of the variables is exactly the same as in the new version of the model

[13] These elasticities are calculated for the 15 year period between 1992 and 2007.

The production equation from the Old Broiler Model, did not take improvements in production efficiencies and genetics that have resulted in a successive improvement in the number of production cycles per annum into account. Further more, by including the input and output prices in the form of a price ratio and not as separate variables, the previous model did not make a distinction between input and output price elasticities. In the New Broiler Model an own price elasticity of 0.19 was estimated and an input cost elasticity of -0.05. The Old Broiler Model produced an elasticity of 0.27 on the output-input price ratio variable.

3.7 MODEL CLOSURE

A partial equilibrium model consists of domestic supply, demand, trade and price components (Meyer, 2006). For a partial equilibrium model to reach equilibrium, total demand has to equal total supply. According to Meyer (2006), there are two main techniques to "close" a recursive simulation model and the choice of closure technique is important as it determines the manner in which market equilibrium is reached in the model. The price and trade components are thus instrumental in the model reaching equilibrium and the choice of "closure" technique should be based on the equilibrium pricing conditions that exist in a particular market.

Market prices of any country are determined by that country's trade and policy regimes (Meyer, 2006). There are essentially three different market regimes, namely import parity, autarky and export parity, only one of which can prevail in a market at any single point in time. Under each of these regimes domestic and world prices are integrated differently. Most econometric simulation models estimate the domestic price as a function of the world price, with the relationship between the dependent and independent variables being estimated as an average over the three regimes. Meyer (2006) noted that although appearing statistically sound, this approach entails a significant simplification of the price formation process.

A market can be described as functioning under an import parity regime when the domestic prices are high enough to attract imports to the point that the country becomes a net importer and the domestic price is a function of the world market price (Meyer, 2006). In this situation, domestic supply increases as imports increase and one can expect a high rate of transmission from the world price to the domestic price.

A market can be considered to be functioning under autarky[14], if domestic prices are between import and export parity (Meyer, 2006). In this situation domestic prices are determined by fundamental factors in the local market, and are largely disconnected from international prices.

Export parity occurs, when domestic market prices are low enough, relative to world prices, resulting in the country being a net exporter (Meyer, 2006). In this situation the domestic price is again a function of the world market price and the rate of transmission from world prices to the domestic market price is high. Domestic market prices are thus expected to be closely related to the price paid in import parity countries, after the deduction of the relevant transportation costs and taxes.

From Chapter 2 it is clear that South Africa is a net importer of broiler meat by a relatively large margin with approximately 20 to 30 percent of all broiler meat being imported. This percentage has also been increasing over time. Therefore, from a theoretical point of view the SA broiler market has been trading at import parity levels for several years, which implies that according to the equilibrium pricing conditions the domestic broiler price should be a function of the import parity prices with no local dynamics influencing the way that equilibrium is reached in the market. Prices are thus estimated in the form of a price linkage equation and the model is closed on net trade. Equation 3.17 defines a very basic price linkage equation for a typical import parity regime.

Equation 3.17: $P_{D,t} = f\,(P_{IP,t})$

The price linkage equation clearly indicates that the domestic price ($P_{D,t}$) is estimated as a function of the import ($P_{IP,t}$) parity price, which implies that there should be a

[14] Autarky, by definition, refers to an economic policy or situation in which a nation is independent of international trade and not reliant on imported goods i.e. no trade takes place under autarkic conditions as domestic prices trade at levels where no arbitrage is triggered (Meyer, 2006).

very high level of price transmission between the international price and the local price. Price transmission refers to the extent to which price changes in one market, lead to price changes in another market (Brooks and Melyukhina, 2005). These relationships are important in agricultural commodity models as they are, amongst others, at the core of trade policies, domestic producer and consumer policy, product differentiation/ segmentation, and market efficiency (Cluff, 2003).

However, chapter 2 also illustrated (figures 2.18 and 2.20) that there exists a relationship between other meat prices and the broiler price and that the relationship between the import parity price and the domestic price is not very clear. The reason for this is that the imports coming into the country are not complete substitutes for domestically produced broilers and as a result the domestic ex abattoir broiler price could not merely be specified as a function of the import parity price. The industry specialists also argue that although the import parity prices do matter, there is a definite relationship between the prices of the different types of meat and that the broiler price is also influenced by local supply and demand dynamics. In other words, the specification in Equation 3.17 has to be supplemented by domestic variables in order to account for the remaining systematic variance that will otherwise remain in the error term. The formulation of the price equation in the new broiler model is presented in section 3.7.2 below.

Having used the model closure technique where the market solves for equilibrium under an import parity regime and prices are therefore estimated in the form of a behavioural equation, the model is closed using a net imports identity. The net imports identity can be expressed as follows:

Equation 3.18: $NIMP_t = BEGS_t + PROD_t - CONS_t - ENDS_t$

Where $NIMP_t$ stands for net imports, $BEGS_t$ equals the beginning stock, $PROD_t$ stands for local production, $CONS_t$ for local consumption and $ENDS_t$ for ending stocks. The broiler meat net import identity that was used to close the New Broiler Model is presented in section 3.7.2 below.

The change in the model closure technique is the most important step that was taken in the update and re-formulation of the broiler model. In the Old Broiler Model the price equilibrator approach was applied to close the model. Hence, the broiler market was considered to be functioning under autarky with the ex-abattoir price being determined by fundamental factors in the local market, and largely disconnected from international prices. Imports and exports were estimated in the form of behavioural equations. In order to make a judgment on which model closure technique is the more appropriate technique to follow, Chapter 4 presents the simulation results of the two different approaches.

3.7.1 THE SA BROILER MEAT PRICE EQUATION

As was previously mentioned, the initial broiler model applied the price equilibrator approach to close the model. Hence, no estimation of a price equation was required and therefore no direct comparison of price equations can be made between the previous model and the new model. For the New Broiler Model the typical price linkage equation that is applied in the case where a market trades under import parity was not followed and apart from the inclusion of the import parity price, the ex-abattoir price was also estimated as a function of beef prices and local supply and demand dynamics. Equation 3.19 presents the format of the price equation that was estimated for the new broiler model.

Equation 3.19: RCKPPSA = f (RCKIMPP, RBFAPSA, CKPRDSA)

Calculating the import parity price was particularly challenging as the values derived from the SACU data were not considered being reliable (Coetzee, 2006) due to the way in which it was captured. The majority of imports from 2000 - 2001 onwards were from Brazil (based on metric ton volume), while before that they were from the US. This change was partly brought about by production efficiencies, competitiveness in output price(s) as well as a company specific anti-dumping duty that was imposed on US producers during 2000. There is also currently no reason to believe that the origin of broiler meat imports will be from any other country in the near future. No Brazilian price data was found for the period before 1997, and as this price did not have a significant impact on the domestic SA price before 2000, the real US 12-city wholesale price (RCKPUS) was used for the period 1979 – 2000 and from 2001 the real Brazilian export price (RCKEPBRR) was used. These international reference prices were then introduced into the SA broiler price equation after adding the eastbound container freight rate (RCFRR) (with the nominal observations between 1978-2004 and 2005-2007 being extrapolated using the percentage change in the US Oil refinery price). The R2.20 import tariff that was imposed during 1997 (RCKTRFF) was also added to obtain an international reference price that reflects an actual import parity price (RCKIMPP) as closely as possible. This constructed import parity price was used in the model. All of these time series were introduced into the equation after being deflated using the SA CPIF.

The real beef ex auction price (RBFAPSA) was introduced as it is regarded as the alternative animal protein price to which the broiler industry is the most sensitive, as discussed in Chapter 2.

It was also argued that local supply and demand dynamics had to influence the domestic broiler price to some extent. Many attempts were made to include domestic production and consumption, but several different specifications that took relative levels of production and consumption, as well as changes in them, kept returning parameters with an incorrect sign. The model that produced the best statistical results and the parameter with the correct sign included only domestic production and not consumption. This equation is presented in Table 3.10.

Table 3.10: Estimation Results for the New Domestic Broiler Producer Price Equation

Explanatory Variable	**Parameter Value**	**T-Statistic**	**P-Value**	**Elasticity at the Mean**
Intercept	637.542	8.071	0.000	
RCKIMPP	0.092	1.631	0.115	0.073
RBFAPSA	0.421	9.963	0.000	0.487
CKPRDSA	-0.402	-7.897	0.000	-0.331

F-Test 167.243 **p-value** 0.000 **R^2** **0.953** **Durbin –Watson** **1.553**

Despite all the efforts to find a representative import parity price, according to the model with the best statistical fit, there is very little transmission (elasticity = 0.073) that takes place between the Brazilian price and the domestic broiler price. After discussing these results with industry specialists, it was concluded that the heterogeneous nature of chicken imports with respect to the different cuts that are imported makes it very difficult to assign one specific import parity price (in this case, the whole-bird price) to capture all the transmissions that take place between the international market and the local market. In the synthetic approach that was followed in the end, the elasticity of the chicken import parity price was increased marginally to 0.13, to provide some form of transmission from the import parity price onto the local market.

In all estimations, beef prices (RBFAPSA) proved to be highly statistically significant and always produced the correct sign with a meaningful elasticity. This supports SAPA's (2006) point of view (discussed in chapter two) that beef is the price leader for all meat types and has the largest influence on the broiler industry. In the Old Broiler Model where the price equilibrator approach was used, beef prices influenced the broiler market through the per capita consumption equation because beef was included as a substitute for broiler meat. SAPA (2006) argues that the institutional structure of the meat industry is such that the cross price effects are not only determined by consumer behaviour but also by the setting of prices by large processors and retailers. In the final synthetic equation beef prices have the greatest effect on broiler prices with an elasticity of 0.357.

As was previously mentioned, several attempts were made to include both the domestic production and consumption variables in the price equation. Yet, now model was found that accommodated both these variables being statistically and economically significant. However, industry specialists agree that local supply and demand dynamics in the broiler market do have a role to play in the formation of local prices. It is apparent that once the equation that is presented in Table 3.10 was introduced in the BFAP sector modelling framework and various scenarios were tested, the results obtained were skewed by the inclusion of only the production equation. This was the main reason for developing the synthetic price equation (Table 3.11) that includes a ratio of production over consumption, which presents a form of a self-sufficiency ratio with an elasticity of -0.268. The intercept was adjusted accordingly.

Table 3.11 Synthetic Domestic Broiler Producer Price Equation used in the New Broiler Model

Explanatory Variable	Parameter Value	Elasticity at the Mean[15]
Intercept	492.583	
RCKIMPP	0.125	0.134
RBFAPSA	0.218	0.357
CKPRDSA/CKCONSA	-196.630	-0.268

3.7.2 THE SA BROILER MEAT NET IMPORT IDENTITY

As the SA broiler industry has been a net importer since 1986 and there is no evidence that the structure of the market, and thus price formation, will change in the near future, the New Broiler Model is closed on net imports and prices are determined by the equation that was presented in Table 3.11. Exports are not independently modelled but are deducted from imports due to their small size and irregular volumes that are not well modelled using annual averages. Therefore, net imports (NCKISA) are applied as the closing identity by deducting domestic consumption from domestic production as follows:

Equation 3.20: NCKISA = CKPRDSA – CKCONSA

The net import identity has no beginning and ending stock as detailed in Equation 3.18, because there are no sizable stocks held in the country. This is discussed in Chapter 2. If one looks at the relative sizes of these variables it soon becomes clear that the industry is demand driven in the long term, with the size of imports essentially being a function of the difference between consumption (CKCONSA) and production (CKPRDSA).

As was previously mentioned, the closure of the New Broiler Model using a net import identity instead of the price equilibrator equation as used in the Old Broiler

[15] These elasticities are calculated for the 15 year period between 1992 and 2007.

Model, can probably be seen as being the greatest difference between the Old and New Broiler Models. The Old Broiler Model, in contrast to the New Broiler Model, explicitly specified the import and export equations. The import equation's main drivers being excess demand (demand not met by domestic production), and competitiveness based on how the domestic price related to the US price in Rand terms with an additional R2.20 tariff.

Table 3.12: Estimation Results for the Old Domestic Import Equation

Explanatory Variable	Parameter	Elasticity at the Mean[16]
Intercept	67	
MAX(0, ((CKDUSA/CKPRDSA)-1))	321.6	0.3334
(CKPPSA/CKPUSRT)	58	0.9608

Where:

CKDUSA – local consumption

CKPRDSA- local production

CKPPSA – ex-abattoir price

CKPUSRT – import parity price (U.S. based)

The export equation was then essentially specified as the inverse of the import equation, with the parity price (U.S. based) with no tariff being the main difference, and with dummy variables included for 1988 and 1989 when unusually high exports were experienced compared to the rest of the period.

Table 3.13: Estimation Results for the Old Domestic Export Equation

Explanatory Variable	Parameter	Elasticity at the Mean[17]
Intercept	19.249	
MAX(0, ((CKDUSA/CKPRDSA)-1))	-57.17462	-3.5803
(CKPPSA/CKPUSR)	-5.462	-2.4179
DUM98	7.7114	0.0309
DUM99	8.795	0.0336

3.8 CONCLUSION

[16] These elasticities are calculated for the 15 year period between 1992 and 2007.
[17] These elasticities are calculated for the 15 year period between 1992 and 2007.

This chapter laid the theoretical foundations for this study by presenting the theory of supply, demand, and price expectations on which the specifications of the individual equations are based. In this study the demand block effectively consists of consumption and the supply block of net imports together with production, with net imports being the model closing identity.

The estimated parameters are presented together with the results of initial statistical tests indicating how well the equations perform. The estimated equations are generally satisfactory, with the overall statistical significance being high. The fit measured by the R^2 values tend to be a bit high, probably due to multicollinearity. Further validation statistics for the individual equations are presented at the beginning of Chapter 4.

While the overall model cannot replicate all the decisions occurring within the industry, the major behavioural relationships are captured. The extent to which this is true is tested in the latter part of Chapter 4, where the behaviour of the overall system is examined, largely through the use of scenarios where certain impact multipliers and elasticities are captured.

CHAPTER 4

MODEL VALIDATION RESULTS, BASELINE PROJECTIONS, AND IMPACT MULTIPLIERS

4.1 INTRODUCTION

In Chapter 3 the estimated or synthetically induced parameters for the individual equations making up the new Broiler Model were reported and their statistical significance was evaluated using typical statistical tests for individual regressions using OLS estimators where applicable. Although these initial tests indicate that the individual equations fit the historical data well, this does not mean that when they are combined to form a system of equations, that the simulation results will resemble reality (Pindyck and Rubinfeld, 1998). This is because of the dynamic system structure that results from the combination of the individual equations. The other implication, as mentioned in Section 3.8, is that the sensitivity of endogenous variables to shocks to exogenous variables may be different to that indicated in the estimation results of the individual equations.

As a result, this chapter examines the performance of the overall model when linked to the rest of the BFAP Sector Model through: (1) the calculation of the simulation validation statistics for the individual equations as described in Section 3.4.2; (2) the examination of several impact multipliers, in an effort to examine the ability of the model to generate reliable projections of endogenous variables under real-world conditions through the application of a series of "What if…" questions when compared to the simulation of a baseline or reference scenario. The simulation results under the "What if…" assumptions can be seen as projections and not "forecasts" or "predictions" (Ferris, 1998). These simulated shocks are important as they allow us to test the dynamic response of the model to see whether it produces results that are consistent with theory and empirical observation (Pindyck and Rubinfeld).

Using the Old and New Broiler Model specifications, three "What if" questions will be simulated and their impact multipliers compared to each other. The simulations will focus on the broiler models' behaviour when shocked with a reduction in international broiler prices, an extended drought period, as well as an AI outbreak in the South African broiler industry.

4.2 EMPIRICAL MODEL VALIDATION RESULTS

The validation statistics in this section, presented in Tables 4.1, 4.2 and 4.3, have been calculated based on dynamic simulation values.

Table 4.1: Calculated RMSE and RMSE% Values

Variable	Abbreviation	Model	RMSE	RMSE%
Broiler Per Capita Consumption	CKPCCSA**	New	7.27	**0.39**
Broiler Production	CKPRDSA**	New	43.67	**0.04**
Domestic Broiler Price	RCKPPSA**	New	143.5	**0.20**
Net Broiler Imports	NCKISA*	New	-	-
Broiler Per Capita Consumption	CKPCCSA**	Old	2.18	**0.1**
Broiler Production	CKPRDSA**	Old	124.24	**0.17**
Broiler Imports	CKISA**	Old	81.17	**1.80**
Broiler Exports	CKESA**	Old	2.45	**0.84**
Domestic Broiler Price	RCKPPSA*	Old	-	-

* The Variable is specified as an equilibrator function, resulting in the actual and simulated values are identical
** This validation statistics is calculated over the period 1992-2007

The root-mean-square-error percentage (RMSE%) indicates that the largest relative error terms are present for the CKPCCSA equation in the new model with a value of 39%, while the largest calculated RMSE% value for an individual equation is 180% for the import equation in the Old Broiler Model, where the RMSE is 81.17 thousand tons. The largest relative errors in the Old Broiler Model are thus clearly negated through using the net import identity in order to close the New Model, although the residuals with an RMSE% of 20% are introduced through the domestic broiler ex abattoir price (RCKPPSA) equation specification.

Table 4.2: Calculated MSE, MSE% and MAPE Values

Variable	Abbreviation	Model	MSE	MSE%	MAPE
Broiler Per Capita Consumption	CKPCCSA**	New	6.69	0.35	**34.54**
Broiler Production	CKPRDSA**	New	-2.86	0.00	**3.65**

Domestic Broiler Price	RCKPPSA**	New	-124.84	-0.18	**17.96**
Net Broiler Imports	NCKISA*	New	-	-	-
Broiler Per Capita Consumption	CKPCCSA**	Old	-0.79	-0.02	**8.23**
Broiler Production	CKPRDSA**	Old	59.45	0.09	**12.69**
Broiler Imports	CKISA**	Old	53.15	1.1	**116.2**
Broiler Exports	CKESA**	Old	1.59	0.34	**59.8**
Domestic Broiler Price	RCKPPSA*	Old	-	-	-

* The Variable is specified as an equilibrator function, resulting in the actual and simulated values are identical
** This validation statistics is calculated over the period 1992-2007

In the New Broiler Model, the mean-simulation-error calculated for the new per capita consumption equation indicates that the average size of the error term is 6.69 kg/capita, while that of the production equation is 2,86 thousand tons and the average error term of the ex-abattoir price equation is -124.84 c/kg. The mean-simulation-error calculated for the per capita consumption equation, in the Old Broiler Model however, indicates that the average size of the error term is -0.79 kg/capita, while that of the production equation is 59.45 thousand tons and the average error term of the import equation is 53.15 thousand tons and 1.59 thousand tons. The performance of the individual equations when comparing the Old and New Broiler Models highlighted by the MSE, MSE% and MAPE, illustrate the same patterns in performance as the RMSE and RMSE%, with the CKPCCSA in the Old Broiler Model outperforming that in the new model and the CKPRDSA equation in the New Broiler Model outperforms the production equation in the Old Broiler Model. The Import (CKISA) and Export (CKESA) equations in the Old Broiler Model again have the least favourable statistical results.

Table 4.3: Calculated Values for Theil's Inequality Coefficients

Variable	Abbreviation	Model	U^m	U^s	U^c
Broiler Per Capita Consumption	CKPCCSA**	New	0.13	0.14	**0.02**
Broiler Production	CKPRDSA**	New	-0.00	0.38	**0.69**
Domestic Broiler Price	RCKPPSA**	New	-0.00	0.06	**0.20**
Net Broiler Imports	NCKISA*	New	-	-	-
Broiler Per Capita Consumption	CKPCCSA**	Old	-0.17	0.63	**0.29**
Broiler Production	CKPRDSA**	Old	0.00	0.67	**0.15**
Broiler Imports	CKISA**	Old	0.01	0.37	**0.24**
Broiler Exports	CKESA**	Old	0.26	0.07	**0.54**
Domestic Broiler Price	RCKPPSA*	Old	-	-	-

*The Variable is specified as an equilibrator function, resulting in the actual and simulated values are identical
** This validation statistics is calculated over the period 1992-2005

Table 4.3 contains the proportions U^M, U^S and U^C, which as stated in Chapter 3, are three proportions of inequality, that provide a way to break down the simulation error into its characteristic sources, namely the bias[18], variance and covariance proportions respectively.

The U^M values are zero for the CKPRDSA equations as well as the RCKPPSA equation in the New Broiler Model, indicating that bias is not present in the residuals of these equations. The highest U^M statistic value, 0.26 was calculated for the export equation (CKESA) in the Old Broiler Model, indicating that it is the most likely to contain systematic errors.

The U^S (variance proportions) calculated for the equations, are the largest for the CKPRDSA equations and CKISA indicating that they are not as adept at matching the variance of the underlying time series with the worst performer being the production equation in the Old Broiler Model.

The remaining U^C (covariance proportion) values indicate the level of unsystematic error or the remaining error after the deviations from the average values have been taken into consideration. The residuals containing the greatest portion of non-systematic errors are the CKPRDSA in the New Broiler Model and the CKESA as well as the CKPCCSA in the Old Broiler Model. The per capita consumption equation (CKPCCSA) in the New Broiler Model has the lowest calculated U^C value at 0.02,

[18] Where the bias error refers to either the under- or overestimation of the endogenous variables, resulting from the forecasting scheme (Ferris, 1998).

indicating that the residuals of this equation contain systematic components that can possibly still be accounted for, thus improving performance of the overall equation.

The overall performances of the root-mean-square and mean-square statistics as calculated above indicate that on average the New Broiler Model's per capita consumption equation over estimates demand and the CKPPRDSA equation overestimates production (CKPPRDSA), while the opposite is true for the Old Broiler Models. The interpretation and value of these statistics is further complicated by the strong presence of a positive trend that is visible in the actual underlying production, consumption and import volumes. This, together with the fact that the residuals resulting from the different model closures have different units, makes identifying a clear indication of which system is better based purely on these values more difficult. In terms of the overall system the most favourable make up of the residuals, as indicted by the calculated Theil statistics is that of the New Broiler Model, where there is overall less bias represented and a greater non-systematic portion present in the residuals.

4. 3 THE BASELINE

The main objective of modelling the SA broiler industry is to build as realistic a representation of the industry as possible, based on how it functions and what impacts on its interactions with other industries. In order to examine and understand how the models behave when shocks are introduced, a baseline needs to be generated against which various scenarios can be compared (Strauss, 2005). This also enables the performance of the Old and New Broiler Models to be compared and evaluated.

According to Meyer (2006), a baseline projection can be considered to be a simulation of the BFAP Sector Model over a specific period under agreed policies and specific assumptions about macroeconomic economic variables, as well as weather and technological change. The baseline can, therefore, be seen as a "reference scenario" or benchmark of what could happen under a particular set of assumptions. Indeed, it is important to stress that the baseline is itself a single possible market and policy outlook and should, therefore, not be seen as a forecast (Strauss, 2005) and that due to inherent uncertainties, including changes in weather, policies and markets, it is highly unlikely that observed future values will coincide with those simulated in the baseline (Meyer, 2006).

4.3.1 ASSUMPTIONS

A single set of assumptions regarding policy, explicitly included macroeconomic variables, international prices and weather variables, are used in simulating the BFAP Sector Model's Baseline. Policy variables are generally assumed to be the same as they were at the time of the January 2008 BFAP baseline, for the projection period ending in 2015 (BFAP, 2008).

Assumptions for macroeconomic variables are generally based on projections prepared by several institutions, including the Food and Agricultural Policy Research Institute (FAPRI), Global Insight and the Actuarial Society of South Africa (population projection) (Strauss, 2005; Meyer, 2006; BFAP, 2006; BFAP, 2008). Weather conditions, in turn, are assumed to prevail at average levels, both in SA and in the rest of world over the projection period. Tables 4.4 and 4.5 present the projections for macro economic and policy variables as well as international prices that were used to generate the baseline projections for the previous and updated broiler models. It is important to note that the baselines for the broiler industry that are presented in the following section, were generated within the complete BFAP Sector Modelling framework with all the interactions and recursive effects between the commodities included in the model. The baseline projections of some of the other commodities can be viewed in table format in Appendix C.

Table 4.4: Macroeconomic Assumptions, 2008-2015

Variable	Unit	2008	2009	2010	2011	2012	2013	2014	2015
U.S. refiners acquisition oil price	US $/barrel	81.55	80.15	79.47	78.39	76.51	74.06	72.17	71.58
Total population of SA	millions	47.63	47.79	47.96	48.13	48.31	48.51	48.74	48.98
Exchange rate	SA cent/USD	718.01	765.49	809.96	849.55	891.07	934.61	980.29	1028.20
Real GDP per Capita	R	18051.91	18322.69	18689.14	19436.71	20535.39	21729.72	23054.04	24486.20
Disposable income of households	Currt. Rmillion	1,074,358	1,118,349	1,165,520	1,216,241	1,270,225	1,325,557	1,379,219	1,436,728
Disposable income of hh per capita	R	22,920	23,978	25,115	26,339	27,647	28,996	30,322	31,745
GDP deflator	index '95	237.21	246.71	256.88	267.81	279.44	291.36	302.92	315.30
CPI: Food	index '95	227.03	236.12	245.85	256.32	267.45	278.85	289.92	301.77
Average annual prime rate	%	12.56	12.62	12.69	12.75	12.81	12.88	12.94	13.00
PPI: Agricultural Goods	index '95	220.00	228.81	238.24	248.38	259.16	270.22	280.94	292.42
Freight rate (Argentina - SA)	US$/t	98.44	102.00	105.56	109.04	112.47	115.97	119.62	123.38
Container Freight Rate	US$/t	3298.98	3242.35	3214.75	3170.96	3094.82	2995.96	2919.28	2895.38

Source: BFAP Sector Model, January 2008

Table 4.5: International Commodity Price Projections for the Period 2008-2015

Variable	Unit	2008	2009	2010	2011	2012	2013	2014	2015
Yellow maize, Argentinean Rosario, fob,	US$/t	152.29	152.33	151.42	149.94	148.15	146.07	144.31	143.06
Yellow maize, US No.2, fob, Gulf	US$/t	162.80	162.84	161.86	160.29	158.37	156.15	154.27	152.92
Wheat US No2 HRW fob (ord) Gulf	US$/t	289.00	236.97	244.32	243.76	243.76	243.23	242.82	243.26
Sorghum, US No.2, fob, Gulf	US$/t	159.89	161.07	161.40	161.42	160.84	160.13	159.73	159.90
Sunflower seed, EU CIF Lower Rhine	US$/t	510.78	507.35	492.60	484.61	473.74	463.75	453.30	445.20
Sunflower cake(pell 37/38%) , Arg CIF Rott	US$/t	262.50	258.27	251.80	250.00	246.13	240.36	235.62	231.27
Sunflower oil, EU FOB NW Europe	US$/t	1297.56	1328.17	1330.56	1326.02	1324.36	1328.44	1338.75	1352.88
Sunflower oil, EU FOB Argentine (calculated)	US$/t	1199.12	1226.17	1225.00	1216.98	1211.88	1212.47	1219.13	1229.49
Soybean seed: Arg. CIF Rott	US$/t	359.31	351.26	343.67	339.83	335.65	327.82	317.87	308.94
Soybean cake(pell 44/45%): Arg CIF Rott	US$/t	402.50	393.49	384.98	380.68	375.99	367.22	356.08	346.08
Soybean oil: Arg. FOB	US$/t	779.33	797.72	799.15	796.43	795.43	797.88	804.07	812.56
Fishmeal: 64/65%, c&f Hamburg	US$/t	1289.99	1261.11	1233.84	1220.05	1205.05	1176.92	1141.22	1109.17
Nebraska, direct fed-steer	US$/t	1893.92	1859.85	1815.66	1816.56	1831.57	1857.15	1879.59	1908.44
Chicken, U.S. 12-city wholesale	US$/t	1526.05	1548.60	1552.66	1555.56	1559.13	1564.81	1568.92	1573.85
Chicken: Brazilian export price	US$/t	1204.97	1222.78	1225.99	1228.28	1231.10	1235.58	1238.82	1242.72
Hogs, U.S. 51-52% lean equivalent	US$/t	979.53	1058.79	1134.13	1189.37	1123.84	1029.89	1042.17	1088.34
Nieu Zealand lamb	US $/kg	1.80	1.70	1.60	1.50	1.51	1.53	1.55	1.58
Cheese, FOB N. Europe	US$/t	3080.70	3132.65	3122.89	3111.20	3105.06	3110.82	3138.85	3180.83
Butter, FOB N. Europe	US$/t	2144.06	2174.62	2164.79	2168.24	2168.76	2182.70	2210.02	2246.62
SMP, FOB N. Europe	US$/t	2570.15	2616.83	2632.16	2611.05	2572.42	2557.89	2556.76	2557.50
WMP, FOB N. Europe	US$/t	2554.05	2609.37	2602.41	2577.40	2547.48	2529.94	2547.44	2569.16
Barley, U.S. Portland	US$/t	183.47	184.79	184.84	185.92	186.18	185.12	185.73	187.17
Barley, SPG malting scarlett, France FOB	US$/t	297.54	298.63	296.73	295.49	295.49	295.49	295.49	295.49
Canola / Rapeseed Pri - EU 00 cif Hamburg	US$/t	361.15	357.47	356.47	342.94	331.97	325.43	322.52	315.43

Source: BFAP Sector Model, January 2008

Figure 4.1 presents the baselines for the main endogenous variables in the old and new broiled model. For the period 2005-2007 only the actual data are reported and from 2008 – 2015 the simulated numbers for the various models are presented.

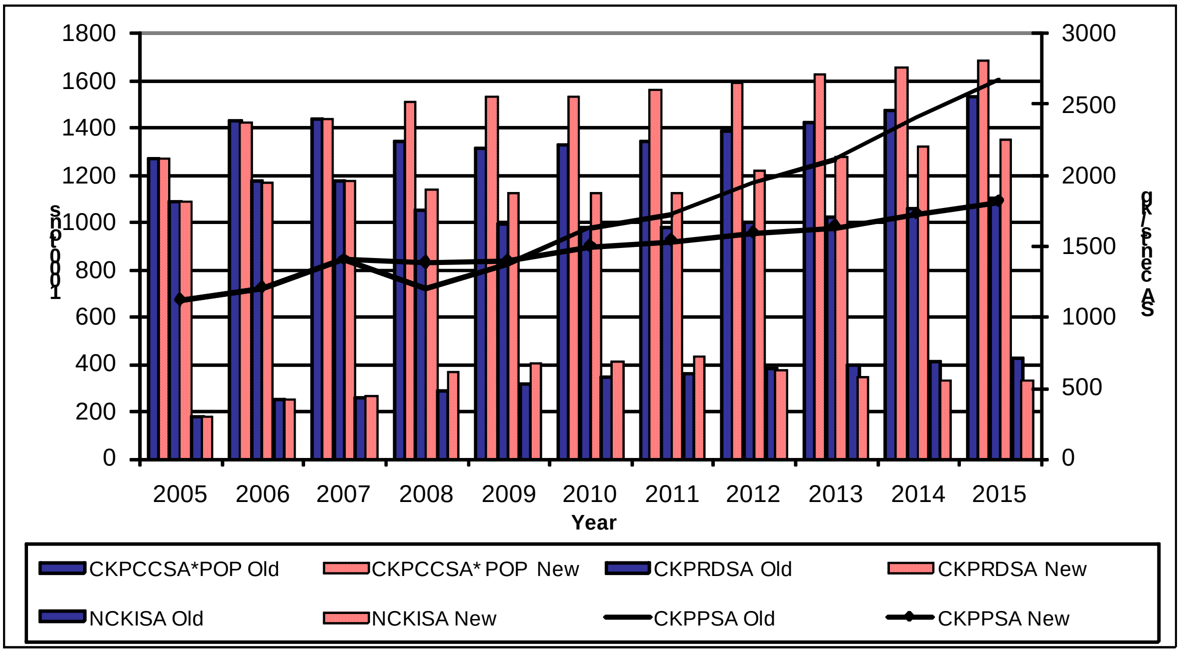

Figure 4.1: Baseline Projections for the SA Broiler Industry, 2005-2015
Source: BFAP Sector Model, January 2008

The Old and New Broiler Models differ significantly, as can be seen in Figure 4.1 and Appendix C. Initially the values are the same for each, as these are the historical/ actual values. After that the values diverge with the New Broiler Model simulating lower ex abattoir prices than the Old Broiler Model. The simulated production and consumption values generated by the New Broiler model are, however, consistently higher than those simulated using the Old Broiler Model. The simulated imports using the New Model are initially higher and then steadily decline with the simulated values being lower than those of the Old Broiler Model from 2012/2103. Looking at the two baselines in isolation, it is not particularly clear which of the two models produces the preferred baseline projections. However, when the outlook of the meat prices is carefully analysed, it is clear that the meat prices in the Old Broiler Model increase at a much faster pace than in the New Broiler Model. In addition, in the previous version the broiler prices trade closer to the beef prices in the outlying years of the baseline projections. Table 4.6 shows that in the baseline projections of the Old Broiler Model the broiler price increases to 85% of the beef price compared to the 5-year average (2002-2007) of 71%, whereas the broiler price in the new baseline is projected at 67% of the beef price.

Table 4.6: Broiler price presented as share of beef price

			2015	
		Actual 5-year avg	Old	New
Beef price	c/kg	1711.4	3186	2696
Broiler price	c/kg	1227.9	2710	1820
Broiler price share of beef price		71.75%	85.06%	67.51%

At this stage there is not a definite indication or reason to believe that a structural shift will occur in the relative pricing of the various types of meat. In other words, the outlook of prices in the Old Broiler Model does not conform to preconceived notions of the structure of the meat industry in the future.

4.5 "WHAT IF" QUESTIONS AND IMPACT MULTIPLIERS

In Chapter 3 several statistical performance measures were discussed for the individual equations, some of the results of which are presented in Section 4.2 above. Another commonly used method to evaluate model performance is the computation of impact multipliers using a deterministic simulation (Calcaterra, 2002). Multiplier analysis is used to gain insight into the ex-ante performance of the model in response to changes in endogenous variables caused by changes in an exogenous variable itself or through exogenously imposed shocks to an endogenous variable. Impact multipliers relate the actual change in a dependent variable (not percentage change) to the actual change induced by an exogenous shock (Ferris, 1998).

In this study the impact multipliers are calculated through the imposition of three different sets of shocks on different variables in the Sector Model. The Sector Model is run for the period 2005-2015 using the new and Old Broiler Model specifications and the simulation results (actual value changes) are reported both graphically and, where appropriate, in table format.

4.5.1 "WHAT IF" QUESTION 1: LOWER INTERNATIONAL BROILER PRICES

What if in 2009, China surpasses broiler production expectations, resulting in lower demand than anticipated, and there is a 10% decrease in the US 12 City Wholesale Price and the Brazilian Export Price? Figure 4.2 presents the scenario results for the New Broiler Model and Figure 4.3 present the scenario results for the Old Broiler Model.

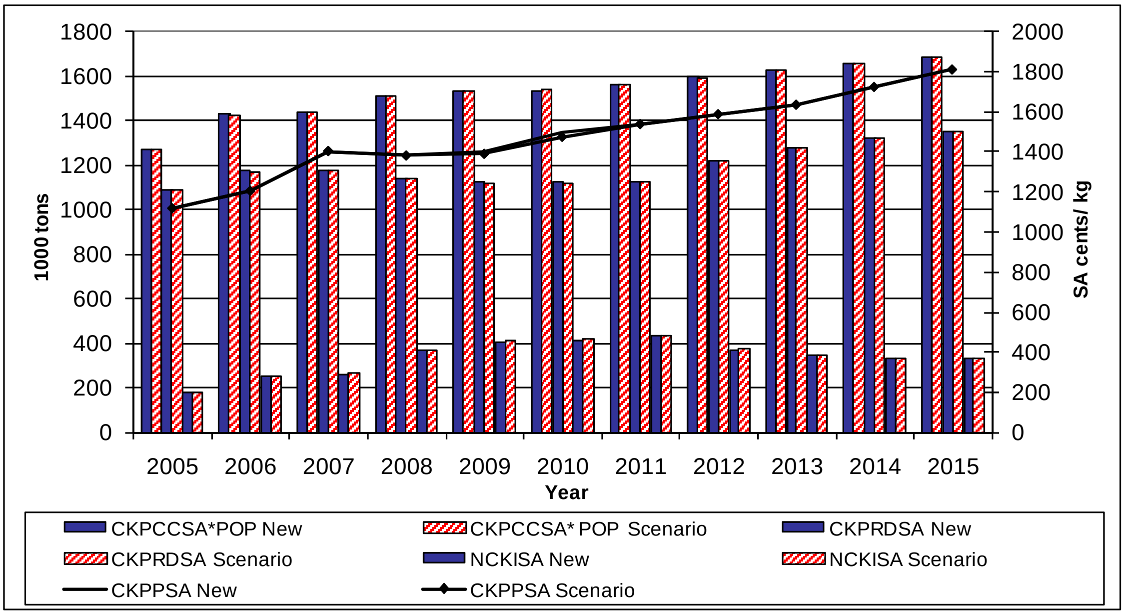

Figure 4.2: Baseline vs Lower International Price Scenario – New Broiler Model

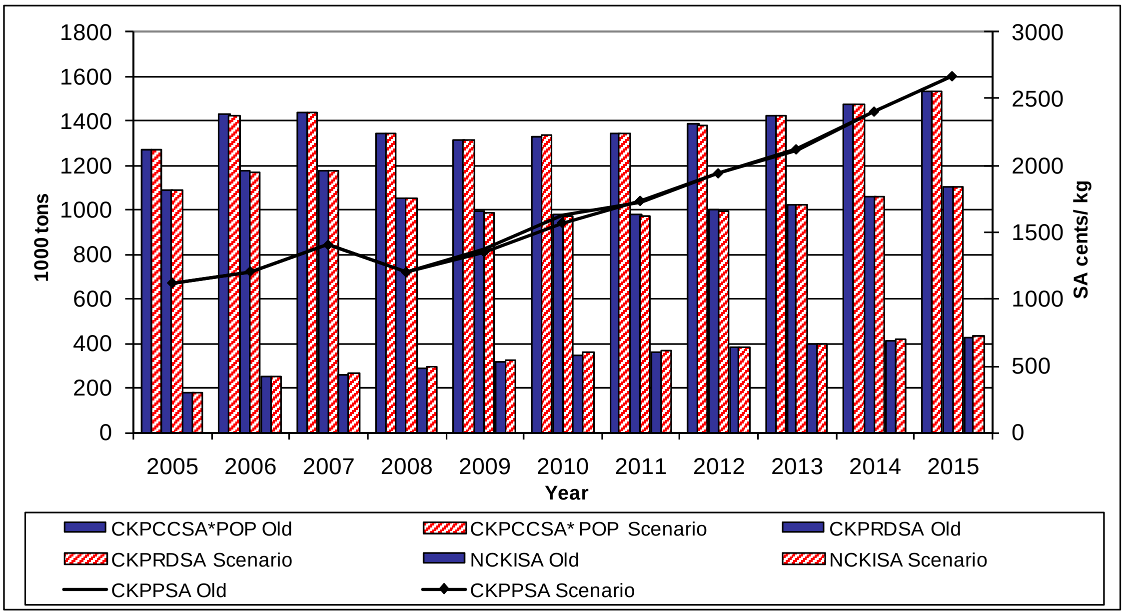

Figure 4.3: Baseline vs Lower International Price Scenario – Old Broiler Model

Comparing Figures 4.2 and 4.3, it is clear that both models have virtually no response to the 10% decline in international prices. In both of the models, the shock results in lower domestic production and lower domestic prices, as is expected. The Old Broiler Model is slightly more sensitive to the movement of international broiler prices than the New Broiler Model, with a decline in the domestic price of 52cent/kg and 23 cent/kg respectively. This implies that the previous version of the broiler model had a greater rate of transmission from the world price onto the local price through the estimated import and export equations than the updated model with a price linkage equation that links the local price to the international price. However, this result could be anticipated because the transmission elasticity of the newly estimated price equation that was presented in Table 3.11 is very inelastic at 0.134.

4.5.2 "WHAT IF" QUESTION 2: 2 YEAR 1992 DROUGHT

What if in 2009 South Africa experiences the onset of drought, with rainfall at the same levels as in 1992, which is regarded as one of the worst droughts in the history of South Africa with respect to the impact on agricultural production. In 2010, the agricultural sector still does not experience any relief and rainfall levels follow those experienced in 1992 again. From 2011 onwards, the average rainfall for the projected period is slightly lower than the average rainfall in the baseline projections in order to account for the low rainfall in the drought years that pulls down the average historic rainfall. For this reason this scenario can be regarded as a continuous shock that runs through the full projection period.

Table 4.7: Shock Rainfall Values for the Period 2006-2015

Variable	Abbreviation	2009	2010	2011
Rainfall: Summer area	RASAD	306.54	306.54	306.54
Rainfall: Summer grain production	RASPRD	366.78	366.78	521.63
Rainfall: Winter area	RAWAD	151.77	151.77	161.10
Rainfall: Winter grain production	RAWPRD	281.33	281.33	266.30

Note: Rainfall is reported in as the average annual average in mm

Table 4.8: Absolute Simulated Values Drought Scenario – New Broiler Model

Variable	2009	2010	2011	2012	2013	2014	2015	Average
CKPCCSA*POP New	1530.68	1533.49	1560.19	1594.12	1628.90	1655.41	1684.51	1598.19
CKPCCSA* POP Scenario	1531.16	1532.26	1560.19	1594.58	1628.45	1656.02	1684.05	1598.10
CKPCCSA Difference	**0.48**	**-1.24**	**0.00**	**0.46**	**-0.46**	**0.61**	**-0.46**	**-0.09**
CKPRDSA New	1122.68	1122.97	1127.35	1220.65	1279.60	1321.70	1353.12	1221.15
CKPRDSA Scenario	1121.18	1122.17	1127.33	1220.40	1279.98	1321.57	1353.33	1220.85
CKPRDSA Difference	**-1.50**	**-0.80**	**-0.02**	**-0.24**	**0.38**	**-0.13**	**0.21**	**-0.30**
NCKISA New	408.00	410.53	432.84	373.47	349.30	333.71	331.39	377.04
NCKISA Scenario	409.98	410.09	432.86	374.18	348.47	334.45	330.72	377.25
NCKISA Difference	**1.98**	**-0.44**	**0.02**	**0.71**	**-0.84**	**0.74**	**-0.67**	**-0.21**
CKPPSA New	1401.75	1502.64	1540.05	1591.11	1637.80	1727.13	1814.16	1602.09
CKPPSA Scenario	1403.01	1510.52	1538.72	1588.67	1639.07	1723.83	1816.46	1602.90
CKPPSA Difference	**1.26**	**7.89**	**-1.34**	**-2.44**	**1.28**	**-3.30**	**2.30**	**0.81**

Table 4.9: Absolute Simulated Values Drought Scenario – Old Broiler Model

Variable	2009	2010	2011	2012	2013	2014	2015	Average
CKPCCSA*POP Old	#####	1327.78	1344.39	1383.23	1422.18	1476.11	1532.90	1400.27
CKPCCSA* POP Scenario	#####	1325.54	1344.68	1383.48	1424.11	1476.10	1534.04	1399.85
CKPCCSA Difference	**-4.35**	**-2.24**	**0.29**	**0.25**	**1.93**	**-0.01**	**1.14**	**-0.43**
CKPRDSA Old	993.63	978.42	978.84	998.78	1022.85	1059.51	1102.27	1019.19
CKPRDSA Scenario	985.72	972.68	979.97	999.66	1026.22	1060.04	1103.79	1018.30
CKPRDSA Difference	**-7.91**	**-5.74**	**1.13**	**0.87**	**3.36**	**0.52**	**1.52**	**-0.89**
NCKISA Old	321.69	349.35	365.56	384.44	399.33	416.60	430.63	381.09
NCKISA Scenario	325.25	352.86	364.73	383.81	397.91	416.06	430.26	381.56
NCKISA Difference	**3.56**	**3.51**	**-0.83**	**-0.63**	**-1.42**	**-0.53**	**-0.38**	**0.47**
CKPPSA Old	#####	1626.00	1721.07	1941.03	2119.95	2408.00	2671.58	1980.83
CKPPSA Scenario	#####	1668.57	1709.98	1932.16	2103.61	2398.69	2668.58	1985.36
CKPPSA Difference	**37.81**	**42.57**	**-11.09**	**-8.87**	**-16.35**	**-9.31**	**-3.01**	**4.54**

The impact of the drought is initially on the input costs of both the Old and New Broiler Model through the feed grain prices that increase on the back of the smaller crop. The impact of higher grain prices on the total costs differs because in the Old Broiler Model 68% of the total costs were attributed to the feed ingredients and in the new model only 55% of the total costs are constituted by the feed ingredients (Table 3.7). Further more, the input cost elasticity in the new model is only -0.05 and in the previous model input costs had an elasticity of -0.27. When the two models are simulated the Old Broiler Model shows a reduction in the local production of broiler meat by 7910 tons, whereas in the new model production only declines by 1500 tons. The lower production levels induce an increase in broiler prices of 37.8 c/kg in the old model and only 1.26 c/kg in the new model. Higher prices feed into the rest of the model as illustrated in Tables 4.8 and 4.9. When these simulation results were discussed with the industry, the general opinion was that the New Model was generating more realistic numbers over the short run (1-2 years) because broiler producers did not have much of an option but to absorb higher prices. However, over the long run the results of the old model are preferred were at least some greater effect is illustrated by the model.

4.5.3 "WHAT IF" QUESTION 3: DOMESTIC AVIAN INFLUENZA OUTBREAK

What if in 2009, it is announced that broilers have tested positive for the H5N1 strain of Avian Influenza (AI) virus. The government then announces that SA broiler exports are banned until the situation has been deemed safe after a period of 6 months to a year. The initially identified infected premises is a large scale broiler farm, 2 more farms are identified as being suspected premises, and the control area is specified in accordance with the "Contingency Plan In Case of An Outbreak Of Notifiable Avian Influenza (NAI) In Poultry In South Africa" (Horner and Pienaar, 2009). Further test results come back positive and further broilers are culled. The culling results in an estimated **10% drop in production[19] for 2009**, while actions taken by the industry and government with regards to information dissemination result in the consumer reaction being limited to a **30% drop in initial demand estimates for the year 2009**. At the end of 2009 an announcement is made that SA has been deemed free of AI and that trade can resume without any added restrictions. This announcement is accepted by the international community and domestic consumers. The Boiler Model results for the simulation for the period 2008-2015 are given in Figures 4.4 and 4.5. It is important to note that there is no recognised linear relationship between the impact of HPAI on production, consumption and the price of broiler meat (Otto et. al., 2009). The impact on production is direct, though the underlying disease and the measures used to counteract its spread. Consumption in turn is impacted indirectly through the level of concern or anxiety that consumers experience with regard to the new of the outbreak (Akben et al, 2008 & Beach et al., 2008), where the level of concern is thought to largely affected by factors such as the level of knowledge about transmission mechanisms, as well as confidence in reports

[19] According to Dr Erasmus (2006) the risk of AI being introduced into SA will not necessarily result in large production losses if very strict biosanitary measures are implemented.

by the media, government and industry (Akben et al, 2008). The combined impacts on supply and demand tend to result in depressed prices (Otte et al., 2009).

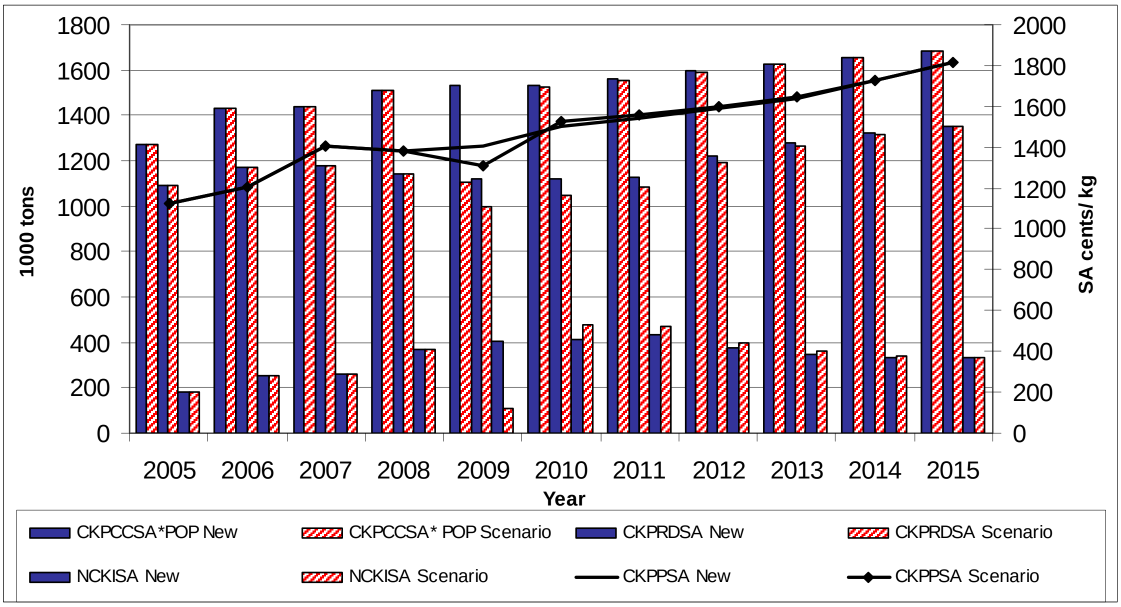

Figure 4.4: Baseline vs Simulated Domestic AI Outbreak Values – New Broiler Model

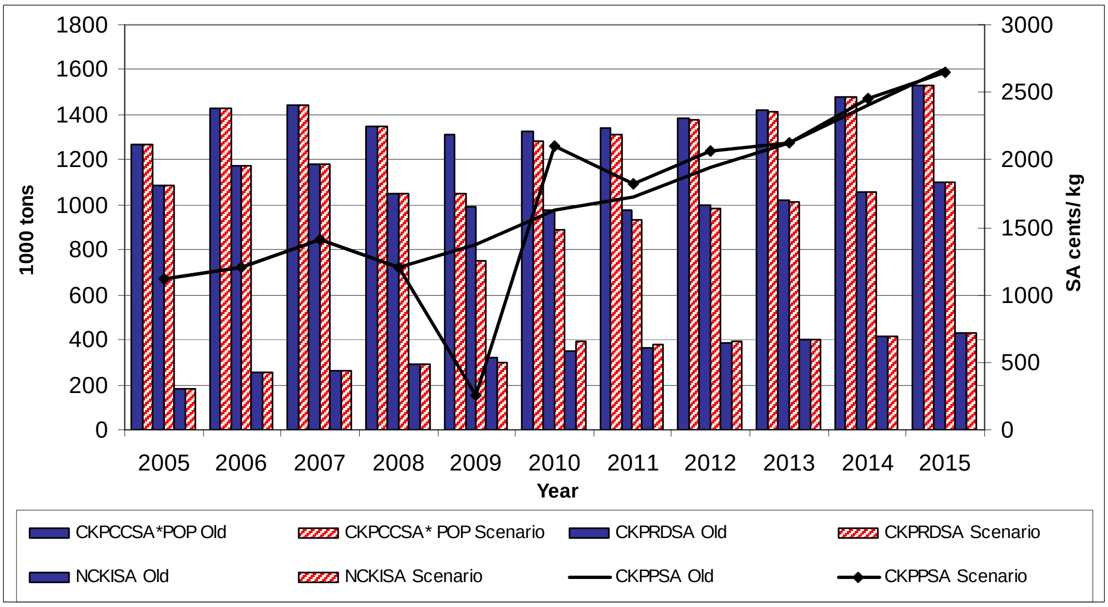

Figure 4.5: Baseline vs Simulated Domestic AI Outbreak Values – Old Broiler Model

This can be regarded as an extreme scenario where the results of the previous and the updated model differed significantly. The Old Broiler Model could not handle a "once off" introduction of the shock, but instead the shock had to be introduced in increments to achieve the final simulation results. The old model simulated a collapse

(78% decline) in broiler prices due to the impact of AI, whereas an 8% decline in broiler prices was projected by the updated model. The impact on prices in the old model seems to be unrealistically large with prices declining to a level where, in the real world, no broiler meat will be traded. On the other hand, the impact on prices in the new model seems to be too low when these shocks are compared to the price shocks that have been recorded in countries where AI has occurred.

It further seems as if the Old Broiler Model did not show any impacts on net trade, with net imports remaining essentially unchanged throughout the scenario. With the collapse in prices, imports have to decrease sharply because there would not be any incentives for a country to export to South Africa given the low prices. The New Broiler Model simulates a sharp decrease in imports in 2009.

The New Broiler Model recovers more quickly than the Old Broiler Model, with no real significant increases in prices during 2010. In both instances the variables indicating the greatest levels of change are those used to close the Broiler Model.

4.6 CONCLUSION

This chapter examines the ability of the New Broiler Model to generate reliable estimates and projections of endogenous variables under real-world conditions, as well as provides a comparison of the performance of the Old and New Broiler Models in terms of baseline and scenario simulations. These performance measures can be seen as supplementary to the statistical validation tests reported and discussed in Chapter 3.

The different structures of the two models are clearly evident when looking at the 3 different scenarios. One of the most significant changes is that of the different model closure technique in the New Broiler Model, which when compared to the Old Broiler Model, seems to be more stable. Although the enhanced stability is useful within the context of the total BFAP sector model, the sensitivity that is lost in the New Broiler Model could lead to the underestimation of the impacts of exogenous factors on the broiler industry.

CHAPTER 5

SUMMARY AND RECOMMENDATIONS

In this study a partial equilibrium broiler model was built using the FAPRI modelling approach, in order to provide an updated representation of the South African broiler industry. This model was introduced in the BFAP sector model in an attempt to improve its performance in the provision of baseline projections and scenario forecasts for agricultural planning and policy development.

The New Broiler Model is built in the context of (1) needs of future users of the model (2) econometric literature and (3) the structure of the broiler industry. The ordinary least squares (OLS) method was used to estimate the initial individual equations and their individual performance was measured using the normal tests associated with the OLS estimation. These test results indicate that all the equations were significant in explaining the behaviour of the dependent variables, namely production (CKPRDSA), per capita consumption (CKPCCSA) and the ex abattoir price (RCKPPSA). Although the initial statistical results indicated a good fit, the introduction of the equations into the BFAP Sector Model as well as mirco-economic theory and a priori expectations based on industry knowledge identified shortfalls in the consumption and domestic price equations. Changes were imposed synthetically in the final CKPCCSA and RCKPPSA equations.

The validation statistics presented in Chapter 4 indicate that the greatest difference between the observed and simulated values for the production, consumption and price equations are unsystematic in nature in the New Broiler Model, while the greatest portion of the residuals was generally accounted for by an inability to match the variance of the underlying time series data in the Old Broiler Model. The validation test statistics also indicate that the new production, consumption and price equations fit the historical data reasonably well. The largest average error term, when compared to the average observed value, is associated with the per capita consumption equation in the New Broiler Model.

The Old Broiler Model was synthetically built as are components of the New Broiler Model, so the only true comparison that can really be made between the models is by comparing the validation statistics presented in Chapter 4 and performance when dealing with scenario type questions. The elasticities and the results for the scenario analyses indicate that the New Broiler Model is generally less sensitive to changes in exogenous factors than the Old Broiler Model. The change in closure of the model, from making use the price equilibrator approach to an approach where a net import identity is used, is the most significant change that was made to the model and has introduced a lot more stability in the broiler model and also the BFAP Sector Model. Although the enhanced stability is useful within the context of the total BFAP sector model, the sensitivity that is lost in the New Broiler Model could lead to the underestimation of the impacts of exogenous factors on the broiler industry. To certain degree one can argue, that the key objective of this study, namely to improve the performance and stability of the broiler model within the BFAP sector model was achieved. However, the advantages over the original broiler model are not as clear as was originally anticipated and there is still substantial work that can be done to improve the model.

The first limitation of the study was that annual data was used to build a partial equilibrium model. Some of the variation and drivers in behaviours are more visible in monthly data and as a result it may be worthwhile to test whether monthly estimates corresponding to different seasons and spikes in demand are statistically different from one another and could add more realism to the model.

Another possible shortcoming of this model is that regime-switching techniques where not further explored. A more aggregate approach was followed where the model is closed on net trade and prices are determined by a combination of parity prices, the domestic beef price and supply and demand dynamics in the domestic broiler industry. Meyer (2006) mentions that this type of approach "entails a significant simplification of the price formation process". Taking the shortage of data into consideration it is recommended that future studies focus on possible threshold levels where a regime switch can be introduced. Given the fact that the trade environment, especially with respect to relative parity prices of non-homogeneous goods changes so fast, this will probably have to entail a synthetic approach since time series data is not available. Information will have to be obtained from industry specialists, traders and retailers because they are well aware of these thresholds where imports are suddenly triggered.

The introduction of retail broiler price(s), being derived in part from the ex-abattoir price, which in turn could be used in the per capita consumption equation, may add more value to the end users, such as government, particularly if this is done for the whole livestock section of the BFAP Sector Model.

Finally, further model improvements through disaggregation and monthly estimation will only be viable if there is further industry participation as the required data would have to be provided by the industry and as such should be viewed as a long term project. More extensive potential change to the New Broiler Model could include the division of the model into different commodity groups (disaggregating the model) so that different part, e.g. cuts, offal and whole broilers, together with a possible differentiation between fresh and frozen, are treated as individual, but linked commodities. This will allow more realistic detail to be included into the price equation, particularly where more appropriate reference prices can be used, e.g. Brazil for offal and US for whole broilers and breast cuts, with different levels of transmission mirroring the different volumes of imports for these products as well as the implications of different policies tariffs imposed on the different tariff lines making the model more relevant in policy discussions.

Increased communication and cooperation between the Department of Agriculture and SAPA, as well as with the Agricultural Research Council (who have recently tried to survey the number and type of backyard chickens in the country), is recommended. This will enable them to align their data and make the best possible estimate of the annual production of chicken meat for publication in the DoA's Abstract of Agricultural Statistics, which represent the SA national statistics.

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APPENDIX A

Table A1: Variable Names

VARIABLE	DESCRIPTION	UNIT
MACROECONOMIC VARIABLES		
POP	Total SA population	Millions
EXCH	SA/USA exchange rate	SA cent/US$
RPCGDP	Real per capita GDP	Rand
GDPD	GDP deflator	Index 1995
CPIF	Consumer price index for food (SA)	Index 1995
CFRR	Container freight rates (US-EU)	US$/t
INTERNATIONAL PRICES		
CKPUS	Chicken: 12-city US wholesale price	US$/t
CKPUSR	Chicken: 12-city US wholesale price	SA cent/kg
CKPUSRT	Chicken: 12-city US wholesale price + CKTRFF	SA cent/kg
CKEPBR	Chicken: Brazilian export price	US$/t
CKEPBRR	Chicken: Brazilian export price	SA cent/kg
POLICIES		
CKTRFF	Chicken import tariff on other: 220 c/kg	c/kg
SOUTH AFRICAN PRICES		
CKPPSA	Chicken producer price	c/kg
BFAPSA	Beef average auction price on hook	c/kg
MUAPSA	Mutton average auction price on hook	c/kg
POPSA	Pork average auction price on hook	c/kg
MPPSA	Min. white or yellow maize price	R/ton
SCPSA	Sunflower cake price	R/ton
SBCPSA	Soyabean cake price	R/ton
SBPPSA	Soybean producer price	R/ton
FMPSA	Fishmeal price	R/ton

Table A1: Variable Names, cont

VARIABLE	DESCRIPTION	UNITS
CONSUMPTION		
CKPCCSA	SA broiler meat per capita consumption	kg/capita
CKCONSA	SA broiler meat consumption	1000 tons
CKDUSA	SA chicken domestic use	1000 tons
PRODUCTION		
CKPRDSA	SA chicken meat production	1000 Tons
LCKPRDSA	SA chicken meat production lagged by 1 year	1000 Tons
BFPRDSA	SA beef and Veal production	1000 Tons
POPRDSA	SA pork production	1000 Tons
MUPRDSA	SA mutton production	1000 Tons
EXPORTS		
CKESA	SA chicken meat exports	1000 Tons
IMPORTS		
CKISA	SA chicken meat imports	1000 Tons
NCKISA	Net SA chicken meat imports	1000 Tons
OTHER		
MBFP Index	Real mutton, beef and pork (red meat) price index (SA)	
CKFCSA	Chicken feed cost index (SA)	R/ton
CKIPISA	Chicken input cost index (SA)	1995 = 100
CKIMPP	Chicken Import Parity Price (SA)	C/kg
DUMMY, SHIFT AND TREND VARIABLES		
DUM81	Dummy variable = 1 in 1981 and zero otherwise	
CKDAYSSA	Chicken: days in production cycle trend (SA)	Days
PREFIXES		
L	Prefix indicating that the variable is lagged	
R	Prefix denoting the variable is in its real	

APPENDIX B

Table B1: Annual Data

Variable	Unit	Source	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
POP	Millions	Actuarial Society	23.43	23.99	24.59	25.22	25.89	26.56	27.24	27.92	28.59	29.25	29.91
EXCH	SA cent/US$	Reserve Bank/IFS	84.2	77.88	87.75	108.59	111.41	147.57	222.78	228.35	203.57	227.26	262.22
RPCGDP	Rand	Reserve Bank	15240.00	15889.00	16347.00	15914.00	15267.00	15689.00	15162.00	14834.00	14825.00	15128.00	15167.00
GDPD	Index 1995	Reserve Bank	11.11	13.88	15.26	17.38	20.26	22.60	26.39	30.90	35.38	40.75	47.78
CPIF	Index 1995	Reserve Bank	10.26	12.21	14.84	16.52	18.47	20.51	23.02	27.69	33.95	39.30	43.64
CFRR	US$/TEU	Ocean Shipping Consultants Ltd											
CKPUS	US$/t	USDA	1022.06	1081.59	1072.55	1023.17	1110.91	1224.67	1120.39	1254.43	1044.33	1241.2	1300.51
CKEPBR	US$/t	FAS Attache Reports											
CKTRFF	c/kg		0	0	0	0	0	0	0	0	0	0	0
CKPPSA	c/kg	NDA	120.88	161.4	173.5	161	181.4	212.82	217.38	289.01	337.86	406.42	383.56
BFAPSA	c/kg	NDA	119	202.4	212.2	211.4	222.9	228.4	257.3	353.4	451.6	482.6	473.6
MUAPSA	c/kg	NDA	120.9	144.3	195	213.7	206.9	233.4	256.3	308.7	384	474.42	531.1
POPSA	c/kg	NDA	99.6	128.6	153.8	164.8	147.4	189.9	214.5	222.4	284.7	324.4	362.2
MPPSA	R/ton	NDA/ SAFEX	100.15	118.25	118.25	134.05	167.55	218.55	218.6	240.35	318	288	268
SCPSA	R/ton	J. Willemse Thesis/AFMA	134	150	181	214	232	262	298	346	389	408	560
SBCPSA	R/ton	J.B Willemse Phd /Malherbe	193	216	265	324	353	398	439	536	603	603	659
SBPPSA	R/ton	NDA/ SAFEX	202	215	241	284	311	360	381	395	466	457	522
FMPSA	R/ton	Malherbe/AFMA	327.50	341.00	378.00	418.00	472.00	512.00	605.00	700.00	829.00	929.00	1310.00
Vegetable oil	R/ton	Dunn/ Calculation	277.13	257.77	295.18	387.12	397.45	588.43	1200.04	1230.81	1110.32	1256.55	1484.99
Vitamin/mineral pack	R/ton	Dunn/ Calculation	458.70	426.66	488.58	640.76	657.84	973.95	1986.27	2037.20	1837.77	2079.80	2457.91
Synthetic lysine	R/ton	Dunn/ Calculation	597.26	555.55	636.17	834.32	856.56	1268.17	2586.28	2652.61	2392.93	2708.08	3200.40
Synthetic methonine	R/ton	Dunn/ Calculation	1075.07	999.99	1145.11	1501.77	1541.81	2282.70	4655.31	4774.69	4307.27	4874.54	5760.73
Other (Enzymes, etc)	R/ton	Dunn/ Calculation	2389.05	2222.20	2544.69	3337.27	3426.25	5072.67	10345.14	10610.42	9571.72	10832.31	12801.61
Limestone	R/ton	Dunn/ Calculation	10.62	14.15	15.71	18.25	21.88	24.73	29.72	35.83	41.91	49.41	59.72
MCP	R/ton	Dunn/ Calculation	94.63	126.03	139.92	162.57	194.86	220.23	264.70	319.15	373.27	440.09	531.89
Salt	R/ton	Dunn/ Calculation	19.26	25.65	28.47	33.09	39.66	44.82	53.87	64.95	75.96	89.56	108.24
CKCONSA	1000 tons	NDA	315	333	351	408	449	469	486	489	533	575.17	601.22
CKPRDSA	1000 Tons	NDA	335	354	383	430	468	484	501	486	528	567	596
BFPRDSA	1000 Tons	DoA	712.2	545.2	591.7	647.3	659	649	604.5	595.5	545.2	542.9	610.3
POPRDSA	1000 Tons	DoA	87.7	88.8	95.7	112	113.6	110.4	107.4	104.3	107.5	114.9	126.2
MUPRDSA	1000 Tons	DoA	182.63	172.26	183.3	212.08	211.45	219.88	193.28	180.79	166.7	164.27	168.23
CKESA	1000 Tons	NDA	20	21	32	22	21	16	17	0	0	1.29	0.82
CKISA	1000 Tons	NDA	0	0	0	0	2	1	2	3	5	9.46	6.04

CKDAYSSA	Days	SAPA 2006/ Own Calculation	48.29	[illegible]	[illegible]	47.2	46.83	46.47	46.1	45.73	45.37	45	44.64

Table B1: Annual Data Cont

Variable	**Unit**	**Source**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
POP	Millions	Actuarial Society	30.58	36.2	36.99	37.8	38.63	39.48	40.58	41.23	42.13	43.05
EXCH	SA cent/US$	Reserve Bank/IFS	258.77	276.09	285.16	326.67	354.97	362.7	429.64	460.73	553.16	611.31
RPCGDP	Rand	Reserve Bank	14806.00	14352.00	13755.00	13637.00	13786.00	13920.00	14218.00	14291.00	14099.27	14086.35
GDPD	Index 1995	Reserve Bank	55.20	63.88	73.18	82.76	90.70	100.00	108.09	116.85	125.86	134.76
CPIF	Index 1995	Reserve Bank	50.64	60.55	75.60	80.98	91.99	100.00	106.18	116.22	123.54	129.80
CFRR	US$/TEU	Ocean Shipping Consultants Ltd					1412	1411	1549	1496	1414	1111
CKPUS	US$/t	USDA	1208.13	1146.4	1159.63	1216.51	1228.12	1242.38	1350.39	1296.48	1389.15	1280.24
CKEPBR	US$/t	FAS Attache Reports								1482.178	1348.78	1208.51
CKTRFF	c/kg		0	0	0	0	0	0	0	220	220	220
CKPPSA	c/kg	NDA	436.67	485.14	536.17	623.17	698.08	711.08	815.92	838.08	802.83	822.08
BFAPSA	c/kg	NDA	474.9	522	521.4	599.6	823.4	752.7	820.9	820.6	786.8	837.9
MUAPSA	c/kg	NDA	503.6	478.6	564.5	621.6	771.1	877.1	826.1	1057.3	1064.5	1012.6
POPSA	c/kg	NDA	340.2	338.1	399	448.3	483.1	623.2	523	632.2	752.1	672.8
MPPSA	R/ton	NDA/ SAFEX	302.67	357.62	445	417	330	410	483.97	580	656.11	787.68
SCPSA	R/ton	J. Willemse Thesis/AFMA	587	600	647	753	769	675	1012	996	916	787
SBCPSA	R/ton	J.B Willemse Phd /Malherbe	716	733	764	855	893	847	1256	1428	1248	1084
SBPPSA	R/ton	NDA/ SAFEX	568	629	745	820	859	930	1200	1391.46	1095.51	1202.65
FMPSA	R/ton	Malherbe/AFMA	1450.00	1560.00	1750.00	1620.00	1740.00	1955.00	2615.00	2994.00	3382.00	2472.00
Vegetable oil	R/ton	Dunn/Calculation	1465.70	1570.84	1624.20	1900.91	2081.21	2127.54	2609.07	2812.60	3518.46	3931.78
Vitamin/mineral pack	R/ton	Dunn/ Calculation	2425.99	2600.02	2688.33	3146.34	3444.76	3521.45	4318.46	4655.34	5823.66	6507.78
Synthetic lysine	R/ton	Dunn/ Calculation	3158.84	3385.44	3500.43	4096.79	4485.37	4585.22	5623.00	6061.63	7582.89	8473.67
Synthetic methonine	R/ton	Dunn/ Calculation	5685.92	6093.79	6300.78	7374.22	8073.66	8253.39	10121.39	10910.94	13649.19	15252.60
Other (Enzymes, etc)	R/ton	Dunn/ Calculation	12635.37	13541.75	14001.73	16387.16	17941.46	18340.86	22491.99	24246.54	30331.54	33894.66
Limestone	R/ton	Dunn/ Calculation	70.69	83.89	98.19	112.98	124.97	139.24	151.50	164.86	178.64	192.23
MCP	R/ton	Dunn/ Calculation	629.61	747.11	874.54	1006.23	1113.01	1240.13	1349.28	1468.31	1590.98	1712.08
Salt	R/ton	Dunn/ Calculation	128.13	152.04	177.98	204.78	226.51	252.38	274.59	298.81	323.78	348.42
CKCONSA	1000 tons	NDA	625.84	571.16	581.79	588.89	641.39	694.98	791.57	874.62	849.3	914.34
CKPRDSA	1000 Tons	NDA	621.84	564.79	564.13	589.87	624.46	669.4	729.16	776.32	776.69	830.19
BFPRDSA	1000 Tons	DoA	664.9	703.5	694	611.2	507.5	507	502.4	496.3	511.7	624.6
POPRDSA	1000 Tons	DoA	130.8	112.7	129.6	119.6	119	126.5	127.9	125	119.2	123
MUPRDSA	1000 Tons	DoA	191.18	176.07	167.35	135.27	94.75	106.27	102.59	96.88	104.93	108.25
CKESA	1000 Tons	NDA	1.79	1.7	3.19	8	3.95	0.99	2.66	4.93	14.28	14.19
CKISA	1000 Tons	NDA	5.8	8.07	20.85	7.02	20.88	26.57	65.07	103.23	86.89	98.34

CKDAYSSA	Days	SAPA 2006/ Own Calculation	44.27	[illegible]	[illegible]	[illegible]	42.81	42.44	42.07	41.71	41.34	40.98

Table B1: Annual Data Cont

Variable	Unit	Source	2000	2001	2002	2003	2004	2005	2006	2007
POP	Millions	Actuarial Society	46.5	46.56	46.86	47.15	46.50	46.80	47.30	47.45
EXCH	SA cent/US$	Reserve Bank/IFS	750.2	860.09	1047	757	622.28	639.44	676.72	709.98
RPCGDP	Rand	Reserve Bank	14287.00	14321.00	14772.69	14996.27	15499.94	16069.14	16653.82	17492.16
GDPD	Index 1995	Reserve Bank	146.64	157.88	174.49	182.53	193.09	202.27	216.13	235.08
CPIF	Index 1995	Reserve Bank	139.81	147.52	170.38	184.37	188.74	193.13	206.85	224.99
CFRR	US$/TEU	Ocean Shipping Consultants Ltd	988	918	826	822				
CKPUS	US$/t	USDA	1238.19	1303.15	1225.77	1366.87	1634.29	1561.31	1419.78	1684.00
CKEPBR	US$/t	FAS Attache Reports	1136	905	1033	829.92	1084.00	1232.82	1121.06	1329.69
CKTRFF	c/kg		220	220	220	220	220	220	220	220
CKPPSA	c/kg	NDA	853	978	1158	1239	1173.00	1121.00	1208.00	1406.83
BFAPSA	c/kg	NDA	837.7	1000	1277.5	1325.5	1424.00	1626.00	1976.00	2040.41
MUAPSA	c/kg	NDA	1300.2	1462.4	1522.3	1818.1	2195.00	2504.00	2986.00	3108.08
POPSA	c/kg	NDA	777.7	899.4	933.9	1219.8	1017.00	1010.00	1189.00	1319.58
MPPSA	R/ton	NDA/ SAFEX	672.88	1168.31	1293.08	1004.39	823.00	794.00	1414.55	1798.52
SCPSA	R/ton	J. Willemse Thesis/AFMA	1085	1463	1649	1545	1210	1250.00	1295.62	1897.30
SBCPSA	R/ton	J.B Willemse Phd /Malherbe	1398	1748	1970	2150	1740	1735.00	1993.26	2539.71
SBPPSA	R/ton	NDA/ SAFEX	1285.54	1242.54	2010.95	2250	1850	1496.66	1814.78	2825.96
FMPSA	R/ton	Malherbe/AFMA	2742.00	3534.00	4778.00	4230.00	4820.00	4253.00	5822.50	6350.00
Vegetable oil	R/ton	Dunn/Calculation	4542.78	7700.61	7441.58	5951.71	5311.24	5461.85	5800	6085.05
Vitamin/mineral pack	R/ton	Dunn/ Calculation	7519.08	12745.84	12317.10	9851.11	8791.01	9040.31	9600	10071.81
Synthetic lysine	R/ton	Dunn/ Calculation	9790.46	16596.14	16037.89	12826.97	11446.63	11771.24	12500	13114.34
Synthetic methonine	R/ton	Dunn/ Calculation	17622.84	29873.06	28868.21	23088.55	20603.94	21188.23	22500	23605.81
Other (Enzymes, etc)	R/ton	Dunn/ Calculation	39161.86	66384.58	64151.57	51307.89	45786.53	47084.95	50000	52457.35
Limestone	R/ton	Dunn/ Calculation	210.80	228.31	255.16	267.49	283.91	298.08	320	348.06
MCP	R/ton	Dunn/ Calculation	1877.48	2033.38	2272.53	2382.30	2528.59	2654.78	2850	3099.91
Salt	R/ton	Dunn/ Calculation	382.08	413.81	462.48	484.82	514.59	540.27	580	632.79
CKCONSA	1000 tons	NDA	955.91	937.35	1,009.35	1,047.91	1137.83	1270.05	1427.92	1440.24
CKPRDSA	1000 Tons	NDA	869.8	866.58	924.85	899.6	905.87	1088.0	1173	1177
BFPRDSA	1000 Tons	DoA	524.9	574	610.2	631.8	672.21	575.65	579.69	601.65
POPRDSA	1000 Tons	DoA	125.8	127.8	129.63	143.1	146.1	150.00	157.25	152.84
MUPRDSA	1000 Tons	DoA	105.37	105.11	114.36	120.33	115.53	102.17	115.85	110.62
CKESA	1000 Tons	NDA	7.24	7.73	9.4	4.7	3.73	2.2	2.5	0.04
CKISA	1000 Tons	NDA	93.36	78.51	93.9	153.01	181.87	184.2	257.4	263.2
CKDAYSSA	Days	SAPA 2006/ Own Calculation	40.61	40.25	39.88	39.51	39.15	38.78	38.42	38.05

APPENDIX C

Table C.1: SA Crop Values Projected for the Period 2008 to 2015 – New Broiler Model

Variable	Abbreviation	Unit	2008	2009	2010	2011	2012	2013	2014	2015
White maize producer price	WMPPSA	R/t	1571.21	1593.71	1623.00	1640.18	1713.75	1765.51	1805.70	1846.62
Maize meal retail price	MMRPSA	c/kg	536.63	554.87	574.84	595.15	621.18	645.96	669.20	693.93
Yellow maize producer price	YMPPSA	R/t	1496.01	1494.34	1641.13	1609.20	1692.25	1788.04	1826.04	1887.68
Wheat Producer price net	WPPSA	R/t	2899.92	2721.94	2922.21	3053.54	3192.45	3330.50	3476.13	3642.68
Barley Producer price	BAPPSA	R/t	2218.79	2214.26	2343.45	2447.98	2562.42	2678.98	2799.27	2931.49
Canola Producer price	CAPPSA	R/t	2564.37	2766.36	2956.66	3083.52	3238.68	3425.45	3640.84	3857.66
Sorghum producer price	SGPPSA	R/t	1175.40	1257.05	1326.29	1374.80	1428.88	1484.12	1536.41	1599.83
Sunflower producer price	SSPPSA	R/t	3249.06	2944.93	3126.01	3473.47	3661.76	3736.19	3864.23	4059.82
Sunflower cake price	SCPSA	R/ton	2269.48	2360.53	2441.04	2531.83	2627.19	2702.60	2763.18	2830.74
Sunflower oil price	SOPSA	R/ton	10855.58	11787.68	12452.20	12976.66	13547.14	14197.64	14948.01	15789.97
Soybean producer price	SBPPSA	R/t	2617.72	2739.65	2842.56	2948.54	3057.77	3133.47	3189.13	3254.05
Soybean cake price	SBCPSA	R/ton	3164.21	3293.85	3403.13	3526.31	3653.17	3742.35	3806.38	3879.95
Soybean oil price	SBOPSA	R/ton	7499.42	8135.52	8641.81	9030.95	9448.83	9917.04	10451.48	11050.76

Source: BFAP Sector Model, 2008

Table C.2: SA Nominal Meat Prices Projected for the Period 2008 to 2015 – New Broiler Model

Variable	Abbreviation	Unit	2008	2009	2010	2011	2012	2013	2014	2015
Beef and Veal Production	BFPRDSA	1000 tons	653.18	689.62	662.35	683.14	666.44	673.44	668.58	682.70
Pork Production	POPRDSA	1000 tons	151.99	150.29	151.22	150.86	151.27	151.45	153.33	155.32
Lamb Production	MUPRDSA	1000 tons	129.11	127.86	127.50	126.15	127.92	129.85	132.63	135.47
Beef ave auction price on hook	BFAPSA	c/kg	2204.28	2058.95	2287.53	2229.88	2320.19	2347.11	2541.54	2696.16
Pork ave auction price on hook	POPSA	c/kg	1461.98	1352.58	1535.47	1511.70	1616.87	1680.36	1889.47	2080.36
Lamb ave auction price on hook	MUAPSA	c/kg	3227.63	3328.90	3461.95	3576.47	3771.90	3977.35	4200.66	4441.90

Source: BFAP Sector Model, 2008

Table C.3: SA Crop Values Projected for the Period 2008 to 2015 – Old Broiler Model

Variable	Abbreviation	Unit	2008	2009	2010	2011	2012	2013	2014	2015
White maize producer price	WMPPSA	R/t	1551.27	1575.83	1602.06	1619.38	1675.91	1724.85	1769.16	1649.00
Maize meal retail price	MMRPSA	c/kg	535.03	553.44	573.16	593.48	618.15	642.71	666.28	424.00
Yellow maize producer price	YMPPSA	R/t	1415.85	1444.36	1594.38	1556.80	1586.80	1661.55	1756.63	1647.00
Wheat Producer price net	WPPSA	R/t	2899.92	2721.94	2922.21	3053.54	3192.45	3330.50	3476.13	1679.30
Barley Producer price	BAPPSA	R/t	2218.79	2214.23	2343.43	2447.95	2562.39	2678.92	2799.20	410.00
Canola Producer price	CAPPSA	R/t	2558.53	2759.77	2948.74	3076.20	3227.22	3413.06	3627.91	706.00
Sorghum producer price	SGPPSA	R/t	1166.63	1250.94	1319.40	1367.45	1414.53	1467.80	1524.31	1680.00
Sunflower producer price	SSPPSA	R/t	3248.98	2944.74	3117.61	3467.54	3659.80	3732.56	3853.12	2783.70
Sunflower cake price	SCPSA	R/ton	2268.70	2359.35	2439.38	2530.07	2624.74	2699.98	2760.60	1202.37
Sunflower oil price	SOPSA	R/ton	10855.58	11787.68	12452.20	12976.66	13547.14	14197.64	14948.01	2665.91
Soybean producer price	SBPPSA	R/t	2613.96	2736.44	2838.50	2944.63	3051.57	3127.08	3182.78	1520.00
Soybean cake price	SBCPSA	R/ton	3162.79	3291.68	3400.10	3523.14	3648.76	3737.62	3801.73	2370.68
Soybean oil price	SBOPSA	R/ton	7499.42	8135.52	8641.86	9030.99	9448.87	9917.10	10451.54	2450.00

Source: BFAP Sector Model, 2008

Table C.4: SA Meat Values Projected for the Period 2005 to 2015 – Old Broiler Model

Variable	Abbreviation	Unit	2008	2009	2010	2011	2012	2013	2014	2015
Beef and Veal Production	BFPRDSA	1000 tons	639.86	692.95	661.01	691.17	671.64	689.91	682.35	703.99
Pork Production	POPRDSA	1000 tons	150.94	150.00	152.18	152.35	154.29	155.26	158.33	161.32
Lamb Production	MUPRDSA	1000 tons	128.70	127.83	128.03	126.81	129.26	131.45	134.75	137.97
Beef ave auction price on hook	BFAPSA	c/kg	2121.14	2032.88	2372.71	2323.40	2532.57	2608.46	2942.33	3186.19
Pork ave auction price on hook	POPSA	c/kg	1387.05	1331.30	1608.24	1593.22	1798.05	1905.92	2234.49	2504.50
Lamb ave auction price on hook	MUAPSA	c/kg	3215.97	3325.89	3471.54	3588.04	3796.75	4009.60	4249.62	4502.87

Source: BFAP Sector Model, 2008