ECONOMETRIC ESTIMATION OF THE DEMAND FOR MEAT IN SOUTH AFRICA

by

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Submitted in partial fulfillment of the
requirement for the degree

M.Sc

in the
Department of Agricultural Economics
Faculty of Natural and Agricultural Sciences
University of the Free State
Bloemfontein

May 2003

Verklaring:

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Pieter R. Taljaard

Acknowledgements

This study was made possible through the help, co-operation and patience of numerous individuals. I wish to thank everybody who made contributions towards this study, several whom I would like to mention by name:

My promoter, Professor Herman van Schalkwyk, for his supervision, faith, encouragement and constructive criticism during this study.

My fellow colleagues in the Department of Agricultural Economics at the University of the Free State, specifically André Jooste an expert on the red meat industry, Zerihun Alemu for his assistance with the modelling, David Spies and Maryn Brusouw for everything they contributed.

My wife, Hilana, for her understanding and moral support, and for being satisfied with less time and attention than she deserved during the past few years.

My parents, for their continuous support on so many levels, the encouragement and example they have set to me all my life.

My parents-in-law, other family members and friends, for their interest during the completion of the study.

The financial assistance of the National Research Foundation (NRF): Social Sciences and Humanities towards this research is hereby acknowledged. Opinions expressed and conclusions arrived at, are those of the author and are not necessarily to be attributed by the NRF.

Finally, to the Almighty for giving me the inner strength and wisdom to complete this study.

Pieter Taljaard

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ABSTRACT

In this study the demand relations for meat in South Africa are estimated and interpreted. Two demand model specifications, namely the Rotterdam and Linearized Almost Ideal Demand System (LA/AIDS), were estimated and tested in order to determine which model provide the best fit for South African meat data.

Tests for separability included an F and Likelihood ratio version. Both tests rejected the null hypothesis of weak separability between meat, eggs and milk as protein sources, indicating that the demand model for meat products should be estimated separately from eggs and milk. Consequently, separability tests between the four meat products fail to reject the null hypothesis, confirming that the four meat products should be modelled together.

According to the Hausman exogeneity test, the expenditure term is exogenous. As a result, a Restricted Seemingly Unrelated Regression (RSUR) was used to estimate both models. Annual time series data from 1970 to 2000 were used. Both models were estimated in first differenced format, whereafter the estimated parameters were used to calculate compensated, uncompensated and expenditure elasticities.

In a non-nested test, the Saragan's and Vuong's likelihood criterion, selected the LA/AIDS model. In terms of expected sign and statistical significance of the elasticities, the LA/AIDS also proved to be more suitable for South African meat data.

Although the magnitudes of most own price and cross-price elasticities were significantly lower than previous estimates of demand relations for meat in South Africa, several reasons, including estimation techniques and time gaps, were offered as explanations for these differences. The uncompensated own price elasticity for beef (-0.7504) is the largest in absolute terms, followed by mutton (-0.4678), pork (-0.36972) and chicken (-0.3502). In terms of the compensated own price elasticities, which contain only the pure price effect, pork (-0.30592) was the most elastic, followed by mutton (-0.27713), chicken (-0.1939) and beef (-0.16111).

The expenditure elasticities of beef (1.243) and mutton (1.181) are greater than one, indicating that beef and mutton are luxury goods in South Africa. The expenditure elasticity for beef is the most elastic; indicating that South African consumers as a whole, will increase their beef consumption as the total expenditure on meat products increase.

EKONOMETRIESE SKATTING VAN DIE VRAAG NA VLEIS IN SUID AFRIKA

deur

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SAMEVATTING

In dié studie is die vraagverwantskappe tussen vleis in Suid Afrika geskat en ge-interpreteer. Twee verskillende modelle, naamlik die *Rotterdam* en die *Linearized Almost Ideal Demand System* (LA/AIDS), is gebruik om te bepaal watter benadering die beste passing vir Suid-Afrikaanse data sal lewer.

Twee toetse vir onderskeibaarheid (*separability*) tussen die verskillende bronne van proteïen is gedoen, insluitende ′n F- en ′n "Likelihood ratio" toets. Beide toetse het die nul hipotese van swak onderskeibaarheid (*weak separability*) tussen vleis, eiers en melk as bronne van proteïen verwerp. Dit beteken dat die model vir die vraag na vleis in Suid-Afrika slegs vleis moet insluit en nie ook eiers en melk soos vooraf vermoed is nie. Vervolgens is die nul hipotese van onderskeibaarheid tussen die vier vleisprodute verwerp, wat ′n aanduiding was dat al vier vleisprodukte in die model teenwoordig moet wees.

Die *Hausman* eksogeniteits toets het getoon dat die bestedings term in die model buite die model bepaal word. Gevolglik kon ′n "Beperkte Skeinbare Onverwante Regressie" (*RSUR*) gebruik word vir skattingsdoeleindes in beide modelle. Jaarlikse tydreeks data vanaf 1970 tot 2000 is gebruik. Beide modelle is geskat in eerste verskilleformat (*first differenced format*), waarna die beraamde koëffisiente gebruik is om die gekompenseerde, ongekompenseerde en bestedings elastisiteite te bereken.

Deur middel van ′n onverwante toets het die Saragan's and Vuong's aanneemlikheidskriteria aangetoon dat die LA/AIDS model 'n beter benadering tot die Suid Afrikaanse vleisindustrie sal wees. In terme van die ekonomiese verwagte teken en statistiese betekenisvolheid van die elastisitiete, is die LA/AIDS ook die beter benadering van die twee.

Alhoewel die groottes van die meeste eie prys en kruiselings pryselastisiteite betekenisvol laer is as vorige skattings, bestaan daar verskeie redes vir die verskille, naamlik ekonometriese skattings tegnieke en tydgapings. Die ongekompenseerde eie pryselastisiteit van beesvleis (-0.7504) is in absolute terme die grootse gevolg deur die van skaap- (-0.4678), vark- (-0.36972) en hoendervleis (-0.3502). In terme van die gekompenseerde eie pryselastisiteite, wat slegs die pryseffekte bevat, kan varkvleis (-0.30592) as mees elasties beskou word, gevolg deur skaap- (-0.27713), hoender- (-0.1939) en beesvleis (-0.16111).

Die bestedingselastisiteit van bees- (1.243) en skaapvleis (1.181) is groter as een, wat impliseer dat bees- en skaapvleis as luukse produkte in Suid Afrika beskou kan word. Omdat die bestedingselastisiteit van beesvleis die mees elastiese is van die vier produkte, kan met redelike sekerheid aanvaar word dat Suid Afrikaanse verbruikers meer beesvleis sal verbruik namate die totale besteding op vleis toeneem.

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LIST OF ABBREVIATIONS

AIDS...................................... Almost Ideal Demand System

Df... Degrees of Freedom

IAIDS .... Inverse Almost Ideal Demand System

LA/AIDS................................ Linearized Approximate Almost Ideal Demand System

LES... Linear Expenditure System

OLS .... Ordinary Least Squares

Translog................................ Transcendental Logarithmic

ECM...................................... Error Correction Model

3SLS .... 3 Stage Least Squares

LR... Likelihood Ratio

Executive summary

Demand Relations for Red Meat Products in South Africa

Various authors have estimated demand relations of red meat products in South Africa in the past. However, all of these estimations dates back before 1994 with the bulk dating as far back as the 1970's and 1980's. These elasticities can not be used for predictions since many structural changes have occurred in South Africa since that time.

From an agricultural decision making perspective, information on the demand relations of the various red meat products can be of great value. Agricultural policy makers and producers organizations will for instance be able to use the elasticities as input parameters in partial equilibrium and equilibrium models which in tern can project for example tariff changes and the effect of import and export prices on the demand for various commodities. Producer organisations and marketers can in turn use this information to do strategic planning, marketing or forecasting.

According to Blanciforti, Green and King (1986) there are basically two approaches when trying to estimate demand systems, the first approach starts with an utility function that satisfies certain axioms of choice. Demand functions can then be obtained by maximizing the utility function subjected to a budget constraint. The majority of demand functions estimated in South Africa used this approach.

An alternative approach, and the one chosen to apply in this study, starts with an arbitrary demand system and then imposes restrictions on the system of demand functions. This approach complies much closer with micro- and macro economic theory compared to the first approach.

In the early 1980's, Deaton and Meulbauer developed the so-called Almost Ideal Demand System, which has proved to be one of the most widely used demand systems. Buse (1993) states that between 1980 and 1991 the Deaton and Meulbauer paper was cited 237 times in the Social Science Citation Index. Closer examination revealed that 68 out of 89 empirical applications used the Linear Approximate (LA) version of the AIDS specification. In agricultural economics, 23 of 25 papers chose the LA/AIDS estimation for the estimation of demand functions (Buse, 1993). However, review on demand studies in South African literature, didn't deliver any citations of the work of Deaton and Meulbauer.

The estimated LA/AIDS model for Red Meat in South Africa includes the following products: beef, chicken, pork and mutton. The Hausman test, suggested by LaFrance (1991), was used to test for Exogeneity of the expenditure variable. The expenditure term in all share equations were found to be exogenous. Edgerton (1993), showed that if the expenditure variable in the model is exogenous, i.e. not correlated with the random error term, the SUR estimators can be accepted as efficient.

Using a Restricted Seemingly Unrelated Regression (RSUR), in MICROFIT 4.1, and enforcing the homogeneity and symmetry restrictions into the LA/AIDS, the demand model for the Red Meat Products in South Africa were estimated. These estimates were then used to calculate compensated, uncompensated and expenditure elasticities together with the corresponding variances which are given in the next three tables.

Table 1: Compensated Elasticities of South African Meat Products

	Beef	Chicken	Pork	Mutton
Beef	-0.16111*	0.139006*	0.375282*	0.060778*
	(0.007789)	(0.007565)	(0.01358)	
Chicken	0.087194*	-0.1939*	-0.1726*	0.173319*
	(0.002977)	(0.0073)	(0.008628)	
Pork	0.053295*	-0.03908*	-0.30592*	0.043108*
	(0.000274)	(0.000442)	(0.007274)	
Mutton	0.020683*	0.094015*	0.103297*	-0.27713
	(0.003196)	(0.005392)	(0.014137)	

* Indicates significance at the 5 percent level, and standard errors are in parentheses.

The compensated own price elasticity (see Table 1) for pork (-0.31) is the most elastic, followed by the own price elasticity for mutton (-0.28), chicken (-0.19) and beef (-0.16). The own price elasticity of beef (-0.16), for example, can be interpreted as: a 1 percent fall (rise) in the price of beef will increase (reduce) the quantity of beef demanded by 0.16 percent. All other own price elasticities reported can be interpreted in a similar way.

Table 2: Uncompensated Elasticities of South African Meat Products.

	Beef	Chicken	Pork	Mutton
Beef	-0.7504*	-0.11017*	-0.07396*	-0.49954*
	(0.014728)	(0.016328)	(0.026546)	
Chicken	-0.28245*	-0.3502*	-0.4544*	-0.17815
	(0.005715)	(0.010743)	(0.01373)	
Pork	-0.03039*	-0.07446*	-0.36972*	-0.03646*
	(0.000415)	(0.000619)	(0.007535)	
Mutton	-0.17985*	0.009223	-0.04958*	-0.4678
	(0.003998)	(0.006404)	(0.015638)	

* Indicates significance at the 5 percent level, and standard errors are in parentheses.

As in the case of the compensated own price elasticities, the uncompensated own price elasticities (see Table 2) also carries the *a priori* expected negative signs and is also statistical significant at the 5 percent level. The uncompensated own price elasticities of beef (-0.75), chicken (-0.35), pork (-0.37) and mutton (-0.47) are significantly lower compared to some of the previous estimates for meat in South Africa. Hancock *et al* (1984) also estimated price elasticities but for the time period 1962 to 1981, which were significantly higher for some products, compared to the figures just mentioned. The own price elasticities, they reported, were: beef (-0.96), poultry (-1.66), pork (-1.86) and mutton (-1.93).

Table 3: Expenditure Elasticities of South African Meat Products

	Beef	Chicken	Pork	Mutton
Expenditure	1.243072*	0.525626*	0.947655*	1.181964
	(0.031107)	(0.039101)	(0.057711)	

* Indicates significance at the 5 percent level, and standard errors are in parentheses.

The calculated expenditure elasticities for South African meat products, which are all positive and statistically significant at the 5 percent level, indicate that all meat can be considered as normal to luxury goods as expected *a priori* (Table 3). Expenditure elasticities for beef (1.24) and mutton (1.18) are greater than one, indicating that they can be considered luxury goods. Although the expenditure elasticity of for pork (0.947) is less that one, it is close enough to one, which is the cut-off point between luxury- and necessary products. The relative low expenditure elasticity of chicken (0.53) gives an indication that chicken can be considered a necessity as a protein source in South African diets.

See appendix A for a more detailed discussion of the progress made to date for the estimation of demand relationships for Red Meat in South Africa. The proposed next steps towards the finalization of the project, includes amongst others; examining the possibility to include eggs and milk as two other sources of protein into the demand model and to show how the results can be used for forecasting and the measurement of policy and welfare effects.

CHAPTER 1

INTRODUCTION

1.1 Background

Red meat constitutes one of the most important agricultural products in the world. This applies in terms of its contribution to the total gross value of production of agricultural commodities, and also in terms of its value in the value adding system of other commodities and products.

The total consumption of meat products in South Africa has increased by over 77% from 0.966 million metric tons in 1970 to 1.713 millions metric tons in 2000. Over the last 30 years, the relative consumption share of the various meat products in terms of Rand value has changed significantly. Since 1970, the share of beef, pork and mutton has decreased by 43.7%, 10.4% and 44.4% respectively. In the case of chicken, an increase of over 46.2% compared to the total expenditure on these four commodities has been experienced. Hancock, Nieuwoudt and Lyne (1984) state that, in spite of this threat to red meat producers, insufficient research has been conducted into the demand for red meat in South Africa. To date only a few studies have been conducted in this field.

According to a study conducted by Liebenberg & Groenewald (1997) no recent studies have been done on the demand relations of red meat products in South Africa prior to that time. Most of the studies cited by Liebenberg and Groenewald (i.e. Du Toit (1982), Hancock *et al* (1984), Du Toit (1978), Cleasby & Ortmann (1991)) were conducted before 1994. After 1994 a considerable number of changes took place, among which such as income distribution changes (shifts between racial groups) and therefore also changes in consumer preferences. These factors have a major impact on substitution effects and therefore on demand relations. Other important effects of the demand for red meat are in the animal feed sector. Animal feed is a derived demand, and any change in the demand for red meat will therefore lead to changes in the demand for different animal feed rations. Although studies have been done to calculate the future demand for livestock products in South Africa these studies were based on outdated demand relations (elasticity coefficients) (Nieuwoudt, 1998).

The liberalization of international markets through trade agreements had and will still have a significant impact on the livestock industry in South Africa. One of the effects of these changes is that commodity prices in South Africa will be closely related to international commodity prices. For example, worldwide consumption of poultry meat is increasing, with exceptional production growth in developing rather than developed countries (10 percent and 7 percent in 1997 respectively). This reflects a number of factors including strong consumer demand for poultry and substitution between poultry and other meat products for health, price and income reasons. Currently there is an international oversupply of pork and certain cuts of chicken. These trends have major effects on local meat industries, specifically price, and therefore on the substitution between different meat products.

During the last two decades, consumer demand analysis has moved toward system-wide approaches. There are now numerous algebraic specifications of demand systems, including the linear and quadratic expenditure systems, the Working model, the Rotterdam model, translog models and the Almost Ideal Demand System (AIDS). Generally, different demand specifications have different implications (Lee, Brown and Seale, 1994).

1.2 Problem statement and need for the study

From the given background, it should be clear that research in the field of meat demand could make a valuable contribution to improving the accuracy of demand change predictions due to two main reasons:

Firstly, since the start of the deregulation process of the agricultural sector in 1994, role players have faced much more volatile market prices, and thus rely on their own analyses and interpretations of these markets for decision making. Various authors have estimated demand relations of red meat products in the past. However, with the exception of Badurally-Adam (1998), most of these estimations date back to before 1994, with the bulk dating as far back as the late 1970s and mid 1980s. These elasticities cannot be used for predictions since many structural changes have occurred in South Africa since that time. These changes have surely had an impact on the demand relations of red meat products.

A **second** reason for concern with regard to the existing demand relations is that, as stated in the previous section, the focus of consumption analysis moved to a system wide approach during the last two decades. The elasticities that currently exist for red meat products in South Africa were estimated by means of more traditional techniques, e.g. single or double log equations. These single equation techniques do not adhere to all the restrictions implied by macroeconomic demand theory, and therefore cannot be used for predictions as the mentioned restrictions can influence the magnitudes of the estimated elasticities. The implications and specifications of the macroeconomic demand theory restrictions will be covered later in this study.

1.3 Objectives

The **overall goal** of this study is to estimate and interpret the demand relations of meat products in South Africa by means of a system-wide approach.

The objectives of the study include:

- The development of a model through which the demand relations can be estimated and easily updated for future use.
- The evaluation of factors affecting the consumption of meat products in South Africa.
- Testing of alternative demand model specifications in relation to each other in order to determine the best fit for the South African meat industry.

1.4 Motivation

Cognizance should be taken of the fact that monitoring a specific commodity market is an evolutionary process. As such, there is no "correct" demand relationship for a specific commodity market (Goddard and Glance, 1989). The question can then rightfully be asked: Why should one allocate all these resources, knowing that there isn't really a "correct" answer to the major question?

As stated earlier, the study of consumer demand patterns over time can provide insight about important factors such as relative prices and income, which will affect future demand patterns. Since the existing demand relations of red meat products in South Africa can be regarded as outdated from an agricultural decision making perspective, newly estimated demand relations of the various red meat products can be of great value.

As a result of the increasing complexity of international and domestic meat markets, role players within the red meat industry require tools that will allow timely and reliable answers to all the "what if" questions. Agricultural policy makers and producer organizations will, for instance, be able to use the results to calculate the effect of tariff changes and import and export prices on the demand for various commodities. This information can, in turn, be used by organizations in the supply chain for strategic planning. It is thus clear that understanding the demand relationships, i.e. price and expenditure elasticities, are critical for accurate impact quantifications of domestic and international policy.

Research in this field could make a valuable contribution to improving the accuracy of demand change predictions.

1.5 Methodology and data used

According to Blanciforti, Green and King (1986) there are basically two approaches for estimating demand systems. The first approach starts with an utility function that satisfies certain axioms of choice. Demand functions can then be obtained by maximizing the utility function subjected to a budget constraint. The Linear Expenditure System (LES), which is described in more detail in Chapter 3, is a typical example of deriving the demand function by means of the optimization process.

An alternative approach, and the one chosen for this study, starts with an arbitrary demand system and then imposes restrictions (macroeconomic demand principles) on the system of demand functions. The Almost Ideal Demand System (AIDS) and the Rotterdam model are two examples of arbitrary demand systems that utilize these restrictions.

In the early 1980s, Deaton and Meulbauer developed the so-called Almost Ideal Demand System, which has proved to be one of the most widely used demand systems. Buse (1994) states that between 1980 and 1991 the Deaton and Meulbauer paper was cited 237 times in the Social Science Citation Index. Closer examination revealed that 68 out of 89 empirical applications used the Linear Approximate (LA) version of the AIDS specification, acronym LA/AIDS. In agricultural economics, 23 of 25 papers chose the LA/AIDS estimation for estimating demand functions (Buse, 1994). A review of demand studies in South African literature didn't deliver any citations of the work of Deaton and Meulbauer.

For estimation purposes, econometric techniques will be used. Simply stated, econometrics means economic measurement (Gujarati, 1999). Other econometricians like Goldberger (1964), defined econometrics as: "The social science in which the tools of economic theory, mathematics and statistical inferences are applied to the analysis of economic phenomena." These two definitions of econometrics could explain why all the mathematical formulas and statistical explanations are necessary in the text that follows this chapter. A more detailed discussion of the methodology used in this analysis is presented in Chapter 4.

1.6 Chapter outline

Chapter 2 presents an overview of some of the applicable demand theory and literature on demand studies that have been covered in applied economics over the last two decades. An overview of the South African red meat sector as well as a description of the time series properties of the data are given in **Chapter 3**. The methodology of the Rotterdam and AIDS models as well as the empirical application of both models on the South African red meat data are covered in **Chapter 4 and Chapter 5** respectively. The document concludes with **Chapter 6** where a test to choose the superior model (Rotterdam versus LA/AIDS) is discussed, whereafter a summary is given and some final recommendations are made.

CHAPTER **2**

LITERATURE REVIEW

"To identify a given relationship, one has to take other possible relationships into account"
- L. Phlips (1974)

2.1 Introduction

Consumer behaviour is frequently presented in terms of preference on the one hand and possibilities on the other. Usually, in demand analysis, the focus is placed on preferences, and possibilities are placed on the background. A possible reason why possibilities are usually given a second place is that possibilities are mostly directly observable. In economic theory, preferences are usually represented in terms of utility functions and the properties thereof.

This chapter provides an overview of economic demand theory and previous red meat demand studies on a local and international level. Selected studies are reviewed in terms of their methodologies, results and findings. The chapter basically consists of 9 parts, with the **first part** providing a summary of consumer utility and demand functions. In the **second part** the concept of two-stage budgeting and separability is covered, whereas the **third and fourth parts** cover the properties of demand functions and elasticities respectively. In the **fifth and sixth parts** the focus is shifted to related studies on international and local red meat demand studies respectively. In the **seventh part**, some of the major changes that have occurred in the econometric analysis framework during the last two decades are discussed as the "old" and "new" econometric methodologies. Criticism against previous meat demand studies is then given in the **eighth part**, whereafter the chapter is concluded.

2.2 Consumer utility and demand functions

The theory and measurement of demand are both more than one hundred years old (Theil, 1980). According to Phlips (1974), the first pioneering attempts in demand analysis were conducted in the early 1930s, and since then, the learning process has been rather slow. It was not until the early 1930s, after the work of Allan and Hick (1934), that economists started to reach consensus (or near-consensus) on consumer demand theory (Phlips, 1974).

Assumptions about consumer behaviour are introduced into the theory of demand through the specification of a utility function. The utility function measures the level of satisfaction an individual experiences as a result of consuming a particular bundle of commodities (goods and services) per unit of time (Johnson, Hassan and Green, 1984). The basics of utility theory are built on the assumption that a consumer purchases goods and services with limited income. Hence, there is a budget constraint on the quantity of goods that a consumer can purchase. To determine the quantities that will be purchased, it is assumed that the consumer has certain preferences, which can be represented by a utility function. A rational consumer will then allocate his limited income among goods and services in order to maximize utility.

Figure 2.1 represents an indifference curve for the utility function with respect to commodity q_1 and q_2. The indifference curve represents the various combinations of q_1 and q_2 that yield the same utility. As shown by Johnson *et al.*, (1984), three assumptions are made when defining a utility function, namely any utility function is strictly increasing, strictly quasi-concave and twice continuously differentiable.

Firstly, the assumption of increasingness implies that the consumer prefers more to less, even if confined to only small changes in the consumption bundle. In the context of Figure 2.1, indifference curves for higher levels of utility than u_0 must lie to the right of $u_0 u_0$ and indifference curves cannot cross. Secondly, the strict qausi-concavity of the utility function prevents the indifference surfaces or contours from containing linear segments or bending back on themselves. Finally, the differentiability assumption assures that the indifference curves are not kinked, as the deviates describing the curvature of the indifference surface are themselves well defined and not kinked (Johnson *et al.,* 1984).

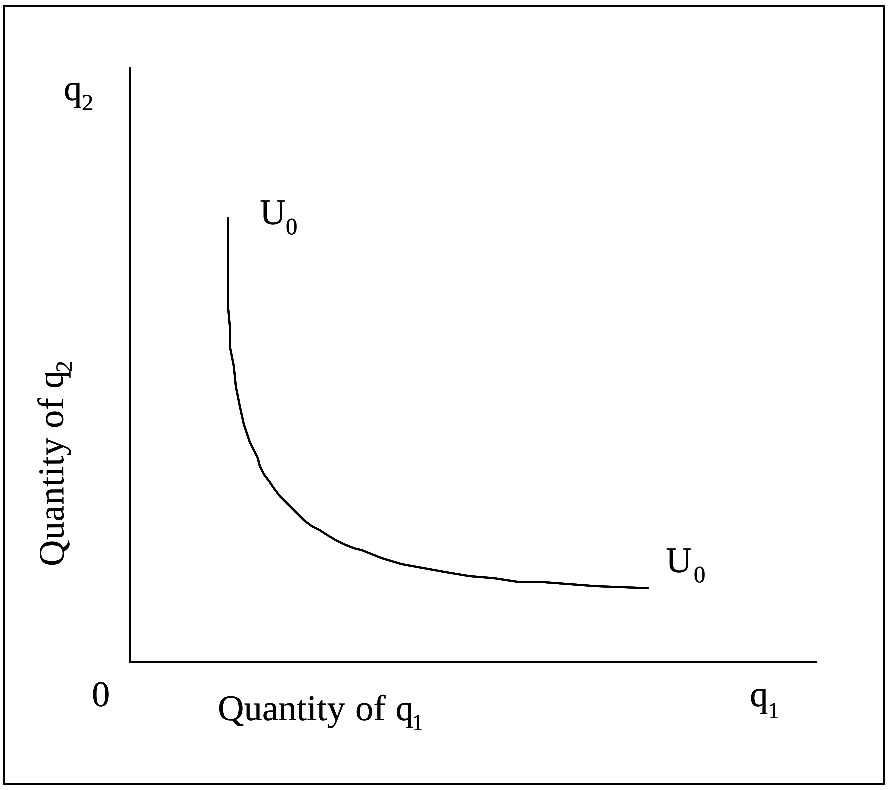

Figure 2.1: A representative indifference curve for a utility function
Source: Johnson *et al.* (1984).

In order to derive a consumer's demand function, a utility function, subjected to a budget constraint, must first be specified. Let *m* for example be the fixed amount of disposable income available to the consumer to allocate between consumption spending and savings, and $p = (p_i, \ldots, p_n)$ the vector of prices of goods and services. The utility maximization problem can then be written as:

$$v(p, m) = Max(u(x))$$

subject to $px = m$,

where *x* is the quantity of the commodity. The function, v(p,m), that gives the maximum utility achievable at given prices and income is called the indirect utility function. The demand function, which is then obtained by differentiating the utility function with respect to the quantity consumed, is important in both theory and practice. More specifically, a demand function describes how a consumer will behave when confronted with alternative sets of prices and a particular income, (Johnson *et al.*, 1984).

Theil (1980) pointed out that it is important to keep in mind that if a utility function is to be maximized, it only represents an ordering of preferences. This implies that utility is viewed as an ordinal concept in the sense that a consumer is supposed to be able to rank different sets of quantities according to decreasing preference. It is thus not assumed that the consumer will be able to state that one set of quantities is say, twice as good as another set. The mathematical implication is that the demand equations, which result from maximizing a utility function subjected to a budget constraint, are invariant under monotone increasing transformations of this function (Theil, 1980).

A major concern with ordinal utility theory pointed out by Theil (1980), is that it provides insufficient guidance in applied demand analysis. This need for more guidance is particularly evident when a large number of commodities are considered. The problem is concealed in the usual elementary textbook treatment, because indifference curves usually refer to only two dimensions. Another concern with the ordinal utility approach and in earlier empirical applications is that demand equations are usually considered one by one, in which the Slutsky symmetry is not an issue.

A solution to this single equation approach is the system-wide approach, which emphasizes equation systems rather than separate equations. One particular problem with systems of demand equations is that the number of Slutsky symmetry relations increase almost proportionally with the square of the number of goods in the system. All the symmetry relations need to be tested simultaneously, and merely only one by one. A further problem is that the number of unconstrained coefficients, which remain after the symmetry restrictions are imposed, increase even more quickly, leading to the degrees-of-freedom problem (Theil, 1980).

The ordinal approach was not accepted for long accepted without criticism. An even more important development by Von Neuman and Morgenson is the concept of cardinal utility (Theil, 1980). In the case of cardinal utility theory, the problem of choice is considered among uncertain prospects. The axioms under which consumers behave are then formulated as if the expected utility will be maximized. This expected-utility approach has been widely used in many areas ever since its formulation in the mid-1940s.

2.3 Two-stage budgeting and separability

Introduced by Hicks (1936) and similarly proved by Leontief (1936), the composite commodity theorem states that if a group of prices move in parallel, the corresponding group of commodities can be treated as a single good (Deaton and Meulbauer, 1999). Deaton and Meulbauer (1999) indicated that this composite commodity theorem is not very useful in constructing commodity groupings for empirical analysis; however, if we assume that relative prices are independent in the long run, commodity grouping should be chosen so that close substitutes in production are grouped together.

Deaton and Meulbauer (1999) suggested that, when an external factor cannot provide consistency to relative prices in order to define commodity groups, preferences could be used instead to structure commodities. As shown in Figure 2.2, a two-stage budgeting procedure assumes that consumers allocate total expenditure in two stages. In the first stage, total expenditure is allocated over broad groups of goods (food, shelter and entertainment). In the second stage, group expenditures are allocated over individual commodities within each group (Jung, 2000).

An advantage of this two-stage budgeting procedure is that in each stage, information appropriate to that stage only is required. In the first stage, allocation must be possible, given knowledge of total expenditure and appropriately defined group prices, while in the second stage, individual expenditures must be functions of group expenditure and prices within that group only (Deaton and Meulbauer, 1999).

A necessary and sufficient condition for the second stage of the two-stage budgeting procedure is weak *separability* of the utility function over broad groups of goods (Jung, 2000). In the case of *separability*, Phlips (1974) stated that, for a function to be separable, the marginal rate of substitution between any two variables belonging to the same group be independent of the value of any variable in any other group. A possible utility tree of consumer goods in South Africa can be illustrated as follows:

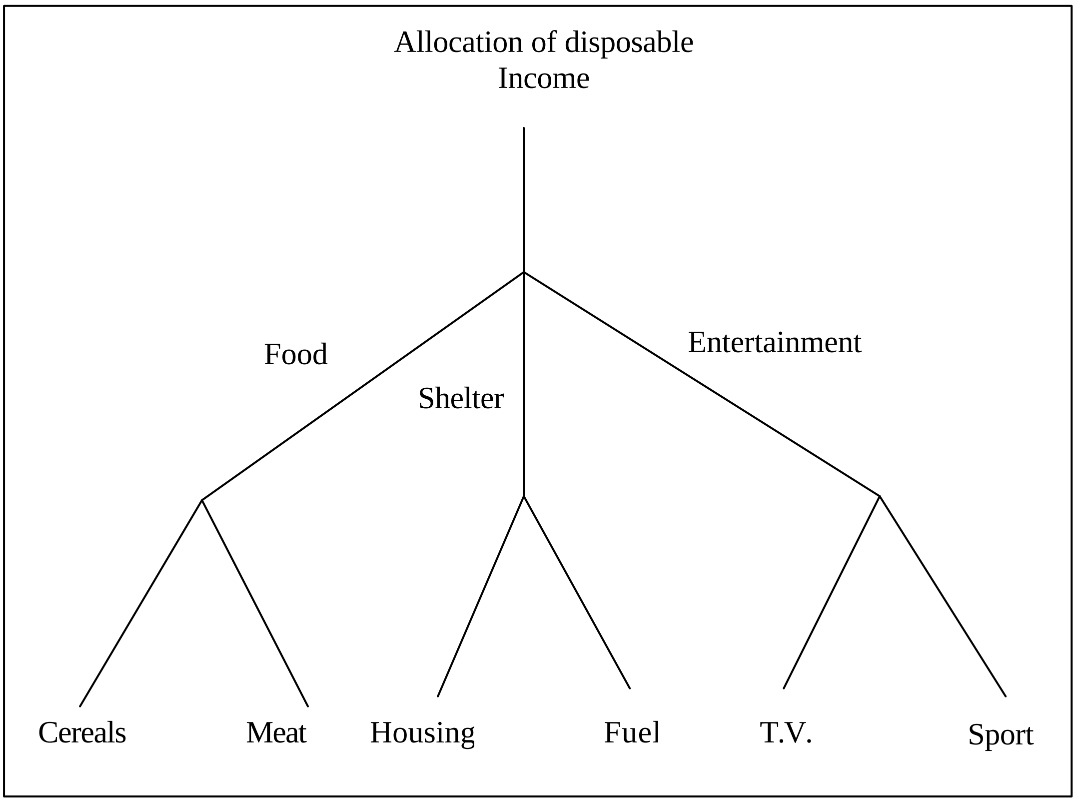

Figure 2.2: Schematic representation of a possible utility tree

Source: Deaton and Meulbauer (1999)

To partition any consumption set into subsets (i.e. the second stage of two-stage budgeting), the concept of *separability* is applied in empirical demand studies so that the estimation model is correctly specified and the number of parameters is limited (i.e. to conserve degrees of freedom) (Eales and Unnevehr, 1988).

2.4 Properties of demand functions

For the sake of completeness, this section is largely based on the description of demand restriction in Deaton and Meulbauer (1999) and Jung (2000). Notwithstanding the importance on non-linear budget constraints, most consumer demand analysis is based of the basic assumption of a linear budget constraint. Mathematically, the linear budget constraint can be given by equation 2.1:

$$x = \sum_k p_k q_k \qquad 2.1$$

Where x is the total expenditure, p_k and q_k represent the price and quantity consumed of product k respectively.

Given that a specific demand function exists, a consumer's choice can be described by means of the *Marshallian* demand function given in equation 2.2. In words, we can say that consumers base their consumption decisions *(q_i)* of a specific product firstly on the total expenditure *(x)* and secondly on prices *(p)* of all goods.

$$q_i = g_i(x, p) \qquad 2.2$$

The properties of a demand function, which can also be tested or used to restrict an empirical application of a demand system, include: aggregation (they add up), the cross price derivatives are symmetric, homogeneous of degree zero in prices and total expenditure, and their compensated price responses form a negative semidefinite matrix. Given the budget constraint in equation 2.1 and the demand equation in 2.2, the four basic properties of demand functions can be given as:

1. The ***adding-up*** restriction limits the demand function to the budget constraint over the observations of prices and income (Deaton and Meulbauer, 1999). Equation 2.3 is an equality, and does not exhaust the implications of the budget constrains. The demand equation has to be such that the sum of the estimated expenditures of the

different commodities must be equal to total expenditures in the period:

$$\sum_k p_k q_k(x, p) = x \quad \text{......} 2.3$$

The adding-up restriction can be expressed by differentiating the budget constraint with respect to x:

$$\sum_{i=1}^{n} \frac{\partial(p_i q_i)}{\partial m} = 1, \quad \text{......} 2.4$$

where $p_i q_i$ is the expenditure on good *i*. According to the adding-up equation in 2.4, the sum of the marginal propensities to consume must be equal to one. This implies that an increase in total expenditures should be allocated entirely to the different commodities (Jung, 2000).

When normal Ordinary Least Squares (OLS) is used for estimation purposes, the adding-up restriction will normally be satisfied automatically, implying that it cannot be tested as such.

2. The ***homogeneity*** restriction, given in equation 2.5, implies that demand function is homogeneous of degree zero. Consider a vector of purchases *q*, and assume that it satisfies the budget constraint given in equation 2.1 for prices *p* and expenditure x. Since the homogeneity restriction is linear and homogeneous in *x* and *p*, the vector *q* will also satisfy the constraint for any multiple of *x* and *p* (Jung, 2000). More formally, for any positive number *?*, and, for all *i* from 1 to n, the homogeneity restriction can be written as:

$$g_i(qx\ ,qp\ ) = g_i(x, p) \quad \text{......} 2.5$$

The homogeneity restriction is also known as the " absence of money illusion" since the units in which prices and outlay are expressed have no effect on purchases

(Deaton and Meulbauer, 1999). Practically the homogeneity restriction implies that if all prices and income are multiplied by a positive constant, ?, the quantity demanded must remain unchanged.

3. A reaction of the quantity of a good demanded to a change in its price can be separated into an income and substitution effect. The income effect reflects the change in the real income of the consumers as a result of the price change. The substitution effect, on the other hand, reflects the variation in quantity demanded resulting from a price change. Changes in prices of goods causes their relative prices to change, which causes a change in quantity demanded even in the absence of an income effect. Both effects result from the same price change. Their sum, the combined effect, is thus equal to the observed variation in quantity demanded. The ***symmetry*** restriction restricts the cross-price derivatives of the demand functions to be identical, that is, for all $i \neq j$:

$$\frac{\partial g_i(x,p)}{\partial p_j} = \frac{\partial g_j(x,p)}{\partial p_i} \qquad \text{2.6}$$

The symmetry restriction thus implies that compensated cross-price effects between any two goods are equal.

4. The **n*egativity*** restriction implies that the n-by-n matrix formed by the elements $\partial g_i / \partial p_j$ is negative semidefinite, for any vector ?:

$$\sum_i \sum_j x_i x_j \frac{\partial g_i}{\partial p_j} \leq 0 \qquad \text{2.7}$$

If ? is proportional to p, the inequality becomes an equality and the quadratic form is zero. From equation 2.7, it is clear what the law of demand implies, that is that compensated demand functions can never slope upwards.

2.5 Elasticities

A more convenient and useful way to express demand system restrictions are in elasticities rather than in derivatives. Price elasticities of demand are easily understood and often used by economists to describe the change in quantity demanded as a result of a change in the price of the specific or a related commodity. In layman's terms an own price elasticity of demand can be interpreted as the percentage change (increase or decrease) in quantity demanded as a result of a 1% increase or decrease in the own price of the product.

One of the important uses of estimated demand systems is the evaluation of changes in income and prices. These independent variables of the demand system cannot be viewed independently. The decomposition of these changes is accomplished by using the results of Slutsky (1915) and Hicks (1946), as showed by Johnson *et al... (*1984).

Uncompensated or Marshallian price elasticities contain both the income and price effects, whereas compensated or Hicksian elasticities, on the other hand, are reduced to contain **only price effects**, and are thus compensated for the effect of income on demand.

As shown by Johnson *et al...* (1984), the decomposition of the total effect of a price change can be illustrated by Figure 2.3. According to Slutsky, income is defined in terms of the original bundle of goods. This implies that the price change is accompanied by an income change that enables the consumer to purchase the original basket at the new or changed prices.

Somewhat different to the Slutsky approach, Hicks argued that the price change is accompanied by an income change and positions the consumer on the initial indifference curve. The change in the relative disposable income of the consumer then allows the movement to another indifference curve.

In Figure 2.3, the combined effect of the price change for q_1 is represented by the change in the consumption level for q_1, indicated by the projected point from a to b. As defined by

Hicks, the pure substitution effect is from point a to point c_1, whereas the income effect associated with the price change is from point c_1 to point b.

In this study three different elasticities are used, namely; Own price, cross-price and expenditure elasticities. Firstly, own price elasticity measures the change in quantity demanded given a 1% change in the own price of the product. Based on economic theory, normal goods are expected to have negative own price elasticity, thus the own price elasticities for meat products in South Africa are expected all to be negative.

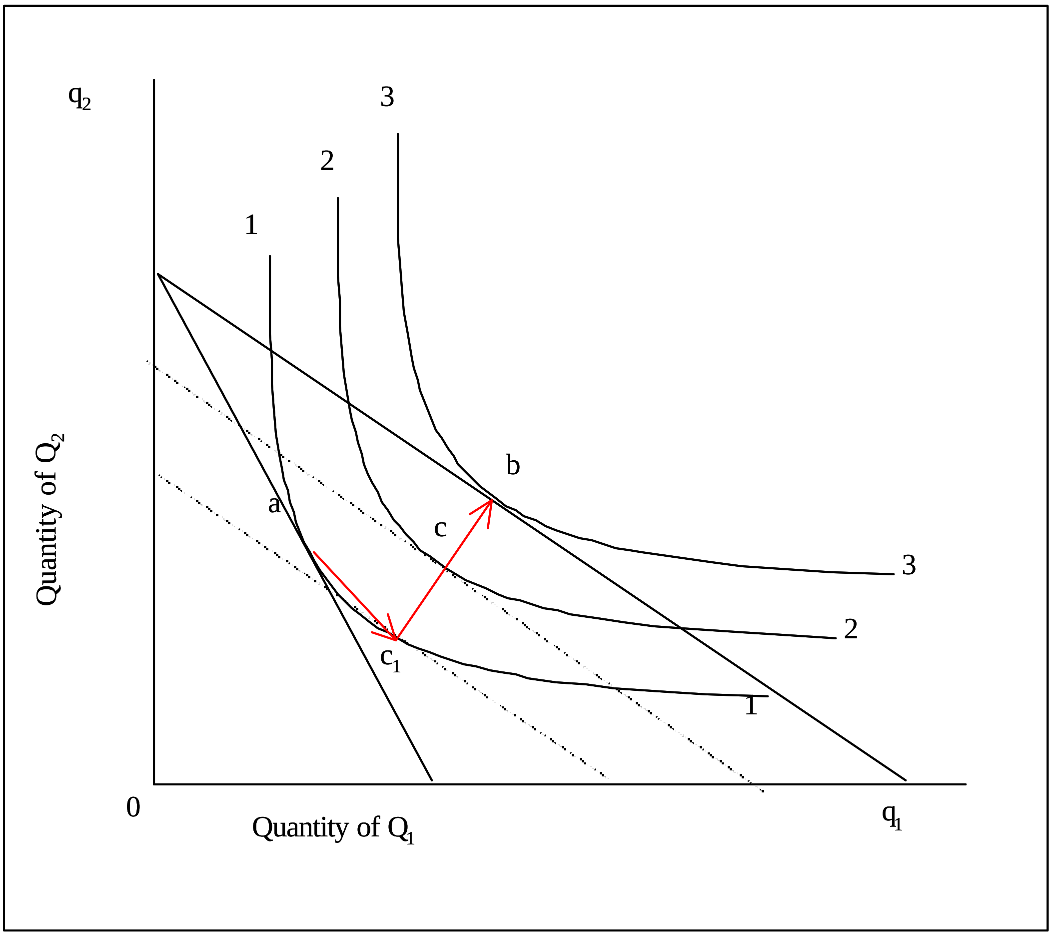

Figure 2.3: Substitution and income effects, the Hicks and Slutsky compositions

Source: Johnson *et al.* (1984).

Secondly, cross-price elasticities show the competitive or complementary relations amongst products. A positive cross-price elasticity indicates substitute products, while negative cross price elasticity represents complementary products. Due to the nature of meat products in South Africa, the cross-price elasticities for meat products are expected to be positive, thus substitutes.

Lastly, expenditure elasticity measures the expected change in quantity demanded of a specific product, as the expenditure on a bundle of goods is increased. All products can be grouped into three groups. If the calculated expenditure elasticity is positive and greater than one, the product is classified as a luxury product. A positive expenditure elasticity ranging between 0 and 1 indicates a normal product, whereas a negative expenditure elasticity is indicative of an inferior product. Due to the fact that the local population in South Africa considers meat to be relatively expensive, the expenditure elasticities for meat products in South Africa are all expected to be positive. The magnitude of the expenditure elasticity of a specific product will thus depend on the product itself.

2.6 Overview of theoretical demand systems

Theory provides the framework within which data can be organized and interpreted. In the next section a brief overview of three of the most important demand models used in previous studies is given. All the models attempt to describe in different ways the way in which total outlay (expenditure) is decided.

Only empirical studies applied to meat demand are covered here, and thus can not be seen as a complete historical survey of applications in demand theory. The models covered roughly represented in chronological order, includes the Linear Expenditure System, the Rotterdam model and the Almost Ideal Demand System.

2.6.1 The Linear Expenditure System and Stone's analysis

As mentioned earlier, early demand analysis was characterized by the extensive use of single equation techniques centred on the measurement of elasticities. Even today, economists use the concept of elasticities discovered by Alfred Marshall during the early 1900s. The reason for the popularity of this concept is that it is easily understood, conveniently dimensionless, and can be measured directly as parameters of linear regression equations in the logarithmic form of prices, purchases and outlays (Deaton and Muelbauer, 1999).

In an effort to construct a cost-of-living index, which depends only upon observable prices and properties of demand functions, Klein and Rubin (1947-48) introduced the Linear Expenditure System (LES). The LES begins with a general linear formulation of demand and then algebraically imposes the theoretical demand restrictions of adding-up, homogeneity and symmetry. Equation 2.8 represents the LES that satisfies these restrictions:

$$p_i q_i = p_i g_i + b_i (x - \sum p_k g_k) \qquad 2.8$$

Richard Stone (1954) then, further modified the linear expenditure system and specified it as follows:

$$\log q_i = a_i + e_i \log x + \sum_{j=1}^{n} e_{ij} \log p_j \qquad 2.9$$

where q_i is the quantity demanded of the i^{th} good; p_j is the nominal price of the j^{th} good; x is the total expenditure on the group of goods being analysed; e_i is the total expenditure elasticity, and e_{ij} is the Marshallian cross-price elasticity of the i^{th} demand on the j^{th} price.

Stone (1954) further described the separation of price elasticities into income and substitution effects as follows. For unrelated goods, substitution effects may be zero, but there is good reason to believe that the income effect might be non-zero. Stone then utilized the Slutsky equation to decompose cross-elasticities into income and substitution effects. The Slutsky equation can be given by:

$$e_{ij} = e^*_{ij} - e_i w_j \qquad 2.10$$

e^*_{ij} is the compensated cross-price elasticity. The budget share of the i^{th} good, w_i, can be defined by:

$$w_i = p_i q_i / x \;, \qquad \ldots\ldots 2.11$$

with p_i, q_i and x the same as described earlier.

Substitution of 2.11 into 2.8 returns:

$$\log q_i = a_i + e_i\{\log x - \sum_k w_k \log p_k\} + \sum_{k=1}^{n} e^*_{ik} \log p_k \qquad \ldots\ldots 2.12$$

The expression $\sum_k w_k \log p_k$ can also be thought of as the logarithm of the general index of prices, log P, such that 2.12 becomes:

$$\log q_i = a_i + e_i(\log x / P) + \sum_{k=1}^{n} e^*_{ik} \log p_k \qquad \ldots\ldots 2.13$$

In other words, equation 2.12 can be interpreted as the quantity demanded in terms of real expenditure and “compensated” prices.

Stone proceeded by imposing the homogeneity restriction from equation 2.5, and in this case in the form:

$$\sum_k e^*_{ik} = 0 \qquad \ldots\ldots 2.14$$

By making use of equation 2.14, Deaton and Meulbauer (1999) similar to Friedman (1976), show that equation 2.13 becomes approximately equal to:

$$\log q_i = a_i + e_i(\log x / P) + \sum_{k \in K}^{n} e^*_{ik} \log(p_k / P) \qquad \ldots\ldots 2.15$$

The set k is a closed group of substitutes and complements, and zero substitution between unrelated products can now be accepted.

The LES has been applied to various empirical demand analyses over the years, but the search continued for alternative specifications and functional forms. Equation 2.15 is thus the basis for the first theoretically consistent demand system used in applied work. It thus serves as the starting point for all applied demand analysis where, after transformations were made; to conserve degrees of freedom (df) and to minimize the effect of serial correlation in the residuals.

2.6.2 The Rotterdam model

The Rotterdam model is one of two most frequently used models in applied demand analysis. First, proposed by Theil (1964) and Barten (1966), it was named after their then domicile, Rotterdam (Deaton and Meulbauer, 1999). The approach is in many ways very similar to the LES. The specification of the model and theoretical restrictions as well as the empirical application of the model on the South African meat data are handled in Chapter 4.

2.6.3 The Almost Ideal Demand System

What can be seen as the most recent major breakthrough in demand system generations is the AIDS, developed by Angus Deaton and John Meulbauer in the late 1970s.

During the last two decades, the AIDS and Rotterdam models have gained prominence in demand analysis, especially in the field of agricultural economics. Alston and Chalfant (1993) indicated that, in a comparatively short time since the AIDS was introduced, it has been widely adopted by agricultural economists, to the point that it now appears to be the most popular of all demand systems. In the year following the statement by Alston and Chalfant, Buse (1994) supported their statement by saying that the model of Deaton and Meulbauer had become the model of choice for many applied demand analysts. According to Deaton and Meulbauer (1980), Alston and Chalfant (1993) and Eales and Unnevehr (1994) the popularity of the AIDS can be ascribed to several reasons:

- It is as flexible as other locally flexible functional forms but it has the added advantage of being compatible with aggregation over consumers. It can thus be interpreted in terms of economic models of consumer behaviour when estimated with aggregated (macroeconomic) or disaggregated (household survey) data (Glewwe, 2001).
- It is derived from a specific cost function and therefore corresponds with a well-defined preference structure, which is convenient for welfare analysis.
- Homogeneity and symmetry restrictions depend only on the estimated parameters and are therefore easily tested and/or imposed.
- The Linear Approximate version of the AIDS (LA/AIDS) is **relatively** easy to estimate and interpret.
- The AIDS gives an arbitrary first-order approximation to any demand system;
- It satisfies the axioms of choice exactly;
- It aggregates perfectly across consumers without invoking parallel linear Engel curves;
- It has a functional form which is consistent with known household-budget data.

Some of the other demand systems possess many of these desirable properties, but no one possesses all of them simultaneously, this popularity where the name *"Almost Ideal"* originates. The specification of the AIDS, the linearization thereof, the theoretical demand restrictions to be tested and imposed as well as the empirical application on the South African meat data, are handled in Chapter 5.

2.7 Related studies on International Red Meat Demand Systems

2.7.1 Functional forms

In the first empirical estimate of the AIDS, Deaton and Meulbauer (1980), used annual British data from 1954 to 1974. The model included eight groups of consumer goods. In the same paper, Deaton and Meulbauer (1980) introduced the AIDS model and also listed the advantages of the AIDS over earlier models like the LES, Rotterdam and Translog models. Applied to postwar British data, Deaton and Meulbauer (1980) found the AIDS model capable of explaining a high proportion of the variance of the commodity budget shares. Their results further suggested that influences other than current prices and current total expenditure must be modeled systematically if the broad pattern is to be explained in a theoretically coherent and empirically robust way.

Shocks in an economy may sometimes lead to permanent changes in behavioral relationships. Chavas (1983) further explained that the source of such a structural change may be technological adoption, a shift in consumer preferences, or an institutional change. One way to handle this problem in linear models is to allow the parameters to change as the situation changes so that the model provides a local approximation of the behavioural relationships (Chavas, 1983). The method Chavas developed to identify and deal with structural change problems is based on the Kalman filtering technique. In order to estimate the variance of the random coefficients, Chavas used the one-step-ahead prediction error, as proposed by Akaike (1970).

When applying this technique to U.S. meat demand in the 1970s Chavas identified structural change to have occurred for beef and poultry, but not pork, in the last part of the 1970s. The empirical results suggest that the price and income elasticities of beef have been decreasing in the last few years, while the income elasticity of poultry has been increasing. Furthermore an increasing influence of pork prices on beef consumption was identified. The results also showed that demand elasticity estimates under structural change show a substantial improvement in forecasting error for all years but 1975 (Chavas, 1983).
Eales and Unnevehr (1988) estimated a Dynamic AIDS for meat aggregates and disaggregated meat products. Their study basically addressed two related questions. Firstly, do consumers allocate expenditure among meat by animal origin or by product type, and secondly, does the disaggregation of meat into products in a meat demand model give insight into the causes of structural change (Eales and Unnevehr, 1988). Due to the importance of the dynamics of the data found by previous authors such as Pope, Green,

Eales, Chavas and Blanciforti, Green and King, (cited by Eales and Unnevehr, 1988), Eales and Unnevehr (1988) followed Deaton and Meulbauer and used the first difference form of the AIDS. In order to overcome the non-linearity problem of the AIDS, the Stone's price index was used to linearize the AIDS. It was also further shown that the tests for homogeneity and symmetry in the first differenced LA/AIDS model were not rejected, and thus imposed into the estimation process.

Annual (long term) data covering 1965 – 1985 were used for estimation purposes. The tests for *separability* showed that consumers allocate their expenditure by product type rather than by animal origin. The results also confirmed earlier cross-section results that hamburger (ground beef) and whole birds are inferior goods and chicken parts and beef table cuts are normal goods (Eales and Unnevehr, 1988). In terms of structural change, Eales and Unnevehr found a shift away from beef and towards chicken after 1974, which roughly coincides with other studies on structural change.

Olowolayemo, Martin and Raymond (1993) used two different functional forms, the IAIDS and linear double-log price dependent demand model, to estimate the demand for eight meat categories. Monthly consumer panel data from 1982 to 1986 were used for this analysis. In general the results for the two models are comparable, and the sizes of the estimated coefficients are consistent with economic theory and earlier work involving similar time and product dimensions. However the IAIDS model satisfies theoretical restrictions such as homogeneity, symmetry and adding-up, making it more viable for use in industry analyses such as a price endogenous mathematical programming approach.

Eales and Unnevehr (1994) developed the inverse version of the AIDS model, derived from the distance function, which gives a representation of preferences. This so-called Inverse Almost Ideal Demand System (IAIDS), retains all the desirable theoretical properties of the AIDS model with the exception of consistent aggregation. Applied to U.S. meat demand, the linear approximation of the IAIDS proved to be excellent, with enhanced ease and range of application (Eales and Unnevehr, 1994). The reason for this development, Eales and Unnevehr argued, is that applications of the AIDS model to the demand for perishable commodities, which are produced subject to biological lags, using short-term (monthly or quarterly) market-level time series data, may not be viable. In this case, it seems advisable to specify an inverse demand system, like the case with many food commodities. The assumption is that the quantity is predetermined by production at the market level, and since it is not storable, price must adjust so that the available quantity can be consumed.

Although Eales and Unnevehr (1994) suggested that the IAIDS might be a better approximation in the case of meat demand, most meat demand studies have employed quantity-dependent demand systems, presumably because such systems are consistent with theory. This is supported by Smallwood, Haidacher and Bloylock (1989), in a literature review on demand studies, stated that of 17 studies listed, 14 employed a quantity dependent demand system.

In a study that tried to understand the demand for meat in the European Union (E.U.), Bansback (1995) analyzed meat consumption trends over 40 years in the United Kingdom (UK) and other EU countries. By using a "conventional" and more "popular" approach, Bansback showed that non-economic factors (health, safety, leisure, tastes and preferences, environmental issues, animal welfare, etc.) have been playing a more important part in both the UK and EU countries than economic (price/income) factors. The conventional approach used consumer utility theory as basis, whereas the so-called more popular approach used income as the key determinant of aggregate meat consumption. The study concluded that non-economic factors, which appear to be most important for consumption trends, appears to be associated with perceived health issues, lack of convenience and quality issues.

Jung (2000) estimated a LA/AIDS demand model by means of 3 Stage Least Squares (3SLS) for Korean meat and fish. Due to the rejection of the weak *separability* hypothesis between meat and fish products, Jung included both meat and fish products in the same demand model. The expenditure term was found to be endogenous, therefore the 3SLS method was used to estimate the LA/AIDS model for meat and fish in Korea. Instrumental variables which were added include the first lags of all prices and expenditure variables, disposable income as well as the consumer price index. For estimation purposes, fish products were categorized into three groups, whereas imported beef was separated from domestic (Korean) beef, and the last two products included pork and chicken. Three sets of compensated and uncompensated elasticities were estimated, namely monthly, quarterly and annually. A non-nested test to choose between the LA/AIDS and Rotterdam model indicated that the LA/AIDS fitted the Korean meat and fish industry better that the Rotterdam model.

In a more recent study that also utilizes the LA/AIDS model, Fraser and Moosa (2002) estimated the demand for meat in the United Kingdom. The aim of their study was to show that if a stochastic trend or seasonality or both are assumed *a priori*, then the resulting model may be mis-specified, and any inference based on the estimated values of the coefficients would have problems. It was also further demonstrated that the out-of-sample forecasting power of the correctly specified model is superior. To be able to do this, three versions of the LA/AIDS for meat in the UK were estimated, based on the assumptions of (1) deterministic trend and seasonality (DTDS), (2) stochastic trend and deterministic seasonality (STDS), and (3) stochastic trend and stochastic seasonality (STSS). The Seemingly Unrelated Time Series Equations (SUTSE) similar to the normal Seemingly Unrelated Regression (SUR), were used for analysis purposes. The empirical results of their study and further discussion follow in the next section.

2.7.2 Elasticities

In a study that focused on *separability* and structural change in the US meat market, Eales and Unnevehr (1988), calculated compensated own and cross-price elastisities (see Table 2.1 and 2.2) for aggregate and disaggregate meat products in the U.S.

Table 2.1: Compensated Aggregate US Meat Elasticities

	Chicken	Beef	Pork
Chicken	-0.276	0.25	0.021
Beef	0.052	-0.57	0.171
Pork	.007	0.314	-0.762

Source: Adapted from Eales and Unnevehr (1988)

The equations Eales and Unnevehr (1988) specified for the disaggregated model are respecified with aggregate chicken split into whole birds and cut-up parts plus processed consumption, whereas aggregate beef was divided into hamburger and table cuts. According to Eales and Unnevehr (1988), the results for the disaggregate model reported in Table 2.2 have reasonable signs and magnitude, but fewer price elasticities are significant compared to the aggregate model. More complex relationships were also revealed among the meat products in the disaggregate model, not visible in the aggregate model.

It is further also clear that the average own price elasticities for both aggregate beef and chicken (Table 2.1) are smaller in absolute value than the own-price elasticities of their respective products (Table 2.2).

Table 2.2: Compensated disaggregate US Meat Elasticities

	WHL	P&P	H	TC	PK	FD	OTH	EXP
Whole birds	-0.677	0.426	0.6	-0.176	-0.198	0.317	-1.54	-0.248
Parts & processed	0.464	-0.61	-0.117	-0.21	0.315	-1.101	1.086	0.827
Hamburgers	0.346	-0.069	-2.593	1.593	0.59	0.31	-2.75	-1.573
Table cuts	-0.019	-0.024	0.384	-0.684	-0.022	-0.325	1.256	1.565
Pork	-0.039	0.057	0.212	-0.064	-0.565	-0.105	-0.455	0.04
Non-meat foods	0.007	-0.018	0.018	-0.063	-0.003	-0.614	0.099	0.427

Source: Adapted from Eales and Unnevehr (1988)

Ordinary demand estimation yields elasticities; on the inverse side, the sensitivities are typically measured by flexibilities. Demand for a commodity is typically said to be inflexible if a 1% decrease in the consumption of the commodity leads to less than 1% decrease in the marginal value of that commodity in consumption.

Table 2.3 reports the flexibilities for various meat products as estimated by Olowolayemo *et al.*, (1993). As noted earlier, the study calculated flexibilities for two models, namely the IAIDS and the linear double log. The parameter estimates from the linear double-log model, which are also the direct price flexibilities, were omitted in this text. The flexibilities obtained from both models were comparable in sign and magnitude, with the own flexibilities ranging from –0.0441 to –0.3155 in the IAIDS model and –0.0002 to –0.2739 in the double-log model. Olowolayemo *et al.*, (1993) found all own and cross flexibilities to be less than 1 in absolute value, indicating that a minimal reduction in price will result in larger increase in quantity consumed by consumers. It was also further highlighted that all the flexibilities obtained from the IAIDS model are negative, indicating that consumers consider the products substitutes. These flexibilities further imply very high elasticities, which appear strange.

Table 2.3: Flexibilities for meats in the United States

	Ground Beef	Roasts	Steak	Pork	Other meat	Chicken whole	Chicken parts	Other poultry
Ground beef	-0.2468	-0.0471	-0.1535	-0.2855	-0.1917	-0.0449	-0.0766	-0.0329
Roasts	-0.094	-0.2782	-0.1424	-0.2125	-0.1141	-0.0465	-0.0653	-0.0306
Steak	-0.1693	-0.0856	-0.1702	-0.2439	-0.1517	-0.0493	-0.1000	-0.0397
Pork	-0.192	-0.084	-0.155	-0.3155	-0.1475	-0.0361	-0.0383	-0.0401
Other meat	-0.1754	-0.0618	-0.1316	-0.1933	-0.2635	-0.0581	-0.0476	-0.0341
Chicken whole	-0.1198	-0.0787	-0.1342	-0.1356	-0.1789	-0.1093	-0.1136	-0.1534
Chicken parts	-0.1331	-0.0719	-0.1814	-0.0737	-0.0854	-0.0734	-0.235	-0.0249
Other poultry	-0.1863	-0.0811	-0.1802	-0.3086	-0.1844	-0.0845	-0.0634	-0.0441

Source: Olowolayemo *et al.*, (1993)

Eales and Unnevehr (1994) estimated a quarterly model of U.S. meat demand to illustrate the application of the IAIDS. The non-linear AIDS (NL/AIDS) as well as the LA/AIDS, were estimated and the flexibilities calculated, see Table 2.3. While the match between the elasticities reported in Table 2.1 and the flexibilities calculated for the same period as reported in Table 2.3 are not exact, the parallel is striking (Eales and Unnevehr, 1994).

The annual compensated and uncompensated price elasticities of demand for meat and fish products in Korea estimated by Jung (2000) are reported in Table 2.5 and 2.6 respectively. As explained earlier, the elasticities were also calculated on a monthly and quarterly basis. The magnitude of the three sets of elasticities is similar for all types of data. Among the six meat and fish products included in the model, the own-price elasticity of Hanwoo beef is the largest in absolute terms, followed by imported beef, molluscs, fish, crustaceans, pork and chicken.

Table 2.4: Comparison of flexibilities: NL/AIDS and LA/AIDS

	Beef Q	Pork Q	Chk Q	Scale	Mean share
NL/AIDS					
Beef P	-0.75	-0.044	-0.047	-0.842	0.573
Pork P	-0.187	-0.785	-0.054	-1.026	0.314
Chk P	-0.747	-0.372	-0.611	-1.73	0.113
LA/AIDS					
Beef P	-0.805	-0.019	0.034	-0.79	0.573
Pork P	-0.186	-0.794	-0.073	-1.053	0.314
Chk P	-0.473	-0.473	-0.972	-1.918	0.113

Source: Adapted from Eales and Unnevehr (1988)

Table 2.5: Compensated Elasticities of Korean meat and fish products: 1980 – 89 (Annual)

	HAN	IB	Pork	Chk	FS	CR	MO
HAN	-0.7175	0.0761	0.3760	0.07	0.1662	0.0202	0.0609
IB	0.2826	-0.9169	0.3786	0.07	0.1663	0.0202	0.0611
Pork	0.2642	0.0716	-0.6262	0.07	0.1616	0.0201	0.0603
Chk	0.2601	0.07	0.37	-0.93	0.16	0.02	0.06
FS	0.2701	0.0728	0.3738	0.07	-0.833	0.0202	0.0607
CR	0.2624	0.0706	0.3709	0.0701	0.1613	-0.9796	0.0605
MO	0.0168	0.2328	0.1144	0.0029	0.5239	-0.0063	-0.8745

Source: Jung (2000)

The expenditure elasticities, also reported in Table 2.5, for all meat and fish products are positive and statistically significant at the 5% significance level, implying that they are normal goods. The expenditure elasticities of Hanwoo beef, imported beef, and molluscs are greater than or equal to one, indicating that beef and molluscs are luxury goods in Korea (Jung, 2000). The expenditure elasticities of other meat and fish products are less elastic than other meat products, suggesting that fish and crustaceans are necessities in the Korean diet.

Table 2.6: Uncompensated Elasticities of Korean meat and fish products: 1980 – 89 (Annual)

	HAN	IB	Pork	Chk	FS	CR	MO	EXP
HAN	-1.1327	-0.0357	-0.2149	-0.0418	-0.0893	-0.0118	-0.0349	1.5969
IB	0.1611	-0.9496	0.2057	0.0373	0.0916	0.0108	0.033	0.4671
Pork	-0.029	-0.0073	-1.0434	-0.0089	-0.0188	-0.0025	-0.0073	1.1276
Chk	-0.0289	-0.0078	-0.0412	-1.0078	-0.0178	-0.0022	-0.0067	1.1114
FS	0.216	0.0582	0.2968	0.0554	-0.8663	0.016	0.0482	0.2081
CR	0.0076	0.002	0.0083	0.0015	0.0045	-0.9992	0.0017	0.9800
MO	-0.0438	0.2165	0.0281	-0.0135	0.4865	-0.011	-0.8885	0.2333

Source: Jung (2000)

The three nested models (DTDS, STDS and STSS) estimated by Fraser and Moosa (2002) were compared by means of Likelihood Ratio tests to determine if the apparent differences between the models are statistically significant. From the elasticity estimates reported in the next three tables, it will become clear that the different specifications do impact the magnitude of the elasticity estimated. The compensated price elasticities reported in Table 2.7 indicate that the necessary condition for concavity is satisfied, meaning that the estimates have the correct sings according to theory. The compensated cross-price elasticity estimates show that all meat types are net substitutes with some marked differences between specifications.

Table 2.7: Compensated elasticities for UK meat demand calculated from three different LA/AIDS models

	Beef	Lamb	Chicken	Pork
DTDS				
Beef	-0.96	0.59	0.11	0.32
Lamb	0.35	-0.98	0.32	0.04
Chicken	0.42	0.4	-0.57	0.18
Pork	0.48	-0.01	0.14	-0.54
STDS				
Beef	-0.99	0.5	0.37	0.28
Lamb	0.31	-0.93	0.11	0.12
Chicken	0.31	0.26	-0.63	0.17
Pork	0.37	0.17	0.11	-0.57
STDS				
Beef	-1.00	0.59	0.31	0.27
Lamb	0.35	-0.94	0.18	0.09
Chicken	0.29	0.25	-0.66	0.20
Pork	0.36	0.10	0.11	-0.55

Source: Fraser and Moosa. (2002)

The difference between the uncompensated price elasticities reported in Table 2.8 is more pronounced compared to the compensated elasticities. According to Fraser and Moosa. (2002), the uncompensated cross-price elasticity estimates are sensible, although not all meat types were found to be gross substitutes.

Table 2.8: Uncompensated elasticities for U.K. meat demand calculated from three different LA/AIDS models

	Beef	Lamb	Chicken	Pork
DTDS				
Beef	-1.32	0.37	0.032	0.132
Lamb	0.06	-1.15	0.26	-0.11
Chicken	-0.20	0.16	-0.65	-0.03
Pork	-0.10	-0.31	0.03	-0.79
STDS				
Beef	-1.27	0.26	0.19	0.07
Lamb	0.08	-1.12	0.03	-0.05
Chicken	-0.001	-0.0003	-0.83	-0.06
Pork	-0.03	-0.15	-0.09	-0.85
STDS				
Beef	-1.30	0.36	0.14	0.06
Lamb	0.12	-1.13	0.04	-0.07
Chicken	-0.03	-0.003	-0.85	-0.04
Pork	-0.05	-0.22	-0.07	-0.82

Source: Fraser and Moosa. (2002)

In terms of the expenditure elasticities reported in Table 2.9, the difference between beef and chicken are particularly pronounced (Fraser and Moosa, 2002). The expenditure elasticity estimate falls more closely for beef when moving to the stochastic trend and seasonality models, but for all other meats they increase.

Table 2.9: Expenditure elasticities for U.K. meat demand calculated from three different LA/AIDS models

	Beef	Lamb	Chicken	Pork
DTDS	1.56	0.93	0.33	0.80
STDS	1.24	1.01	0.70	0.89
STSS	1.26	0.99	0.74	0.87

Source: Fraser and Moosa. (2002)

2.7.3 Economic and non-economic factors affecting meat demand

Table 2.10 provides a summary of the most important findings by Bansback (1995) in his study that analyzed meat consumption in the EU. It is clear that in the case of beef, mutton and pork economic factors like prices of products and disposable income of consumers tend to be less important over time compared to non-economic factors, such as health, safety, leisure, tastes and preferences, environmental issues, and animal welfare.

Table 2.10: Relative importance of economic and non-economic factors for the demand for meat products in the EU-12

	Period			
	1955 – 1979		1975 - 1994	
Product	Economic	Non-Economic	Economic	Non-Economic
Beef and Veal	95%	5%	68%	32%
Mutton and Lamb	84%	16%	58%	42%
Pig meat	98%	2%	55%	45%

Source: Compiled from Bansback (1995)

2.8 Previous studies on South African red meat demand

When comparing price elasticities of red meat in South Africa as estimated by various different authors, significant differences are revealed. According to Lubbe (1992), a **first** reason for these differences can mainly be ascribed to differences in real price movements between the time periods covered in the various studies. A **second** reason can be the level, i.e. wholesale or retail, at which the elasticities were estimated. In the **third** place, the time period, i.e. long or short term, over which the elasticities were estimated can also influence the value of the elasticity significantly. A **fourth** and surely one of the most important reasons why estimated demand relationships for red meat in South Africa isn't directly comparable, is the different methodologies that have been used in the estimation process.

The time period and level in the supply chain are two of the economic factors that affect the magnitude of calculated elasticities. Other economic factors that may also influence the calculated elasticities are the number and closeness of substitutes, the general definition of the product and the number of alternative uses for a product and policy instruments (Liebenberg and Groenewald, 1997). For a more in-depth discussion of the way in which all these factors influence calculated elasticities, the reader is referred to Liebenberg and Groenewald (1997).

2.8.1 Functional forms

In an econometric demand and policy analysis study conducted by Hancock *et al.* (1983), own and cross-price elasticities for meat products were estimated on both a short and long-term basis. Long and short-term elasticities and flexibilities were estimated using single and simultaneous equation techniques respectively. In the case of single equations, OLS were used, and in the case of the simultaneous equations, 3 Stage Least Squares (3SLS) were used. These elasticities were also estimated at different stages/levels in the meat supply chain, for example at wholesale and retail levels.

Bowmaker and Nieuwoudt (1990) estimated own price and income flexibilities for beef, mutton and pork in South Africa. Price flexibility coefficients measure the change in price associated with a 1% change in quantity demanded.

Waugh (1964) recommends the use of a quantity-dependent regression equation to estimate elasticity of demand and a price dependent equation to estimate flexibility of demand. Simultaneous equation techniq ues, although regarded as superior to OLS regressions for estimating systems of demand functions, have not been widely used in South Africa (Bowmaker and Nieuwoudt, 1990). In their study, Bowmaker and Nieuwoudt (1990), used the 2 Stage Least Squares (2SLS) procedure to estimate, amongst other things, the short run (monthly) demand equations for beef mutton and pork. All time series data observations were changed into logarithmic form in order to be able to read the flexibilities directly from the equations.

Most of the earlier demand studies were derived by assuming that the three sets of restrictions (adding-up, homogeneity and symmetry) implied by consumer economics theory, applies.

This theorems and derivations regarding preferences, utility functions and demand behaviour, which were typically assumed to hold in earlier demand analyses, actually provide a useful framework for analyzing consumption data. As stated by Glewwe (2001) and in most other recent demand studies, these restrictions shouldn't be taken for granted. Recent applications of these models to empirical data showed how these restrictions can be useful to test whether they hold, using different functional forms that do not directly impose these restrictions, like the Rotterdam or AIDS. These theorems and derivations can thus be useful in evaluating the consistency of a proposed functional form.

The estimates based on reasonable functional forms can furthermore also be used to test the theorems about demand behaviour. If the theorems are rejected by the data, there are two possibilities, either people do not really behave as demand models predicted they will or the functional form is too restrictive (Glewwe, 2001).

Once a functional form that provides sensible results has been identified, it can be used to estimate demand behaviour of interest, such as own, cross-price and expenditure elasticities for red meat in South Africa.

2.8.2 Elasticities

In an econometric analysis of the demand for and the supply of red meat in South Africa, Du Toit (1982) estimated both long and short run price elasticities at retail level for the period 1959 to 1978. Interestingly enough, Du Toit (1982) found that, at retail level, the short-term own price elasticity of beef is higher than in the long run, with the opposite being true in the case of mutton (see Table 2.11). This behaviour of the beef market is contrary to the expectation of a more elastic long-run demand curve (Liebenberg and Groenewald, 1997), who noted further that most consumers of beef tend to vary their consumption in the short run, while in the longer run, their tastes and preferences play a stronger role in determining their consumption. The own price elasticity for pork an poultry in the short term shown in Table 2.11.

Table 2.11: Long and short term own price elasticities for various meats, South Africa (1960 - 1979)

	Beef	Mutton	Pork	Poultry
Long term	-1.21	-2.42	-	-
Short term	-2.2	-1.26	-2.06	-1.9

Source: Hancock *et al..*. (1984)

Table 2.12 reports the long run (retail) elasticities of South African meats calculated by Hancock *et al..*. (1984). Hancock *et al..*. (1984) regarded the own price elasticities of beef (-0.96), mutton (-1.93), pork (-1.86) and poultry (-1.66) as relatively high. Except for beef in the poultry demand equation, all other coefficients behaved according to expectations. Hancock *et al.*, attached little importance to the calculated income elasticities, due to the fact that the elasticities were derived from time series data and that it might include dynamic effects such as changes in income distribution, urbanization, and the structure of the population over time. Flexibilities, omitted in this document, were also calculated for the same period and appeared to be more stable that the quantity-dependent equations.

Table 2.12: Annual (long-run) price elasticities for various meats, South Africa (1962 – 1981)

	Beef	Mutton	Pork	Poultry	Income
Beef	-0.96	0.66	0.72	0.19	0.71
Mutton	0.73	-1.93	0.53	0.41	0.44
Pork	0.77	-	-1.86	0.50	0.73
Poultry	-0.62	1.26	0.98	-1.66	1.12

Source: Hancock *et al..*. (1984)

Short-run or wholesale (quarterly data) price elasticities (see Table 2.13) were further also estimated by means of simultaneous equation techniques. The reason given by Hancock *et al.* (1984), for the high own price elasticity coefficients is similar to that offered by

Liebenberg ans Groenewald (1997), namely that the elasticities are based on quarterly data (short-term data).

Table 2.13: Quarterly (short-run) price elasticities for various meats, South Africa (1962 – 1981)

	Beef	Mutton	Pork	Poultry	Income
Beef	-1.46	0.61	-1.6	0.55	1.64
Mutton	0.02	-1.61	0.65	0.2	1.37
Pork	-0.15	0.15	-4.2	1.13	1.85

Source: Hancock *et al..*. (1984)

Laubscher and Kotze (1984) found significant differences in income elasticities among the different population groups. According to Laubscher and Kotze (1984) these income elasticities, reported in Table 2.14, suggest that non-whites in general and blacks in particular will spend a greater proportion of any increase in their real per capita income on meat and meat products than whites.

Table 2.14: Income elasticities of the demand for meat and meat products by the respective population groups in metropolitan areas (1975)

	Total	Blacks	Whites	Coloureds	Asians
Meat and meat products	0.73	0.48	1.19	0.76	0.69

Source: Laubscher *et al..*. (1984)

In a research report of the Bureau of Market Research, Loubser (1990) reported estimated income elastisities for small categories, for example beef mince, etc. Table 2.15 reports these income elasticities, which were aggregated (weighted) using expenditure data to obtain the income elasticities for different population groups, (i.e. Asians, Blacks, Rural Blacks, Coloureds and Whites).

In a study that developed projections of the demand for livestock products for South Africa for the years 2000, 2010, and 2020, Nieuwoudt (1998) used income elasticities from Neuwoudt (1990) and Loubser (1990). Nieuwoudt (1998) further indicated that the calculated elasticities were all in accordance with economic expectations and are the highest for rural blacks and the lowest for whites in the case of most items. Elasticities for meat (except pork), and cheese, were high for all groups except for whites (Nieuwoudt, 1998).

Table 2.15: Income elasticities of the demand for various meat products by respective population groups in selected areas

	Metropolitain areas					Rural, Transkei and Bophuthat-swana
	All households			Multiple households	Single households	
	Whites	Coloureds	Asians	Blacks		
Beef (bulk)	0.32	0.16	0.65	1.15	1.67	-
Fresh beef	0.25	1.11	2.57	0.84	1.1	1.59
Beef mince	0.25	0.53	2.15	1.01	1.03	0.55
Beef bones	0.25	-0.62	0.76	0.59	0.44	0.36
Mutton (bulk)	0.22	0.17	1.9	1.28	1.35	-
Fresh mutton	0.27	1.36	0.57	1.77	1.22	1.66
Fresh pork	0.13	1.06	0.01	-	-	0.18
Bacon and bacon scraps	0.55	1.35	2.10	0.71		0.32
Poultry (bulk)	0.26	-0.21	1.11	0.64	0.69	-
Fresh and frozen poultry	0.39	0.65	1.04	0.7	0.56	1.33

Source: Loubser (1990)

Badurally Adam (1998), used the Rotterdam model to estimate the demand for South African meat (beef, chicken, mutton and pork) during 1971 – 1995. They further identified the possible impacts of a Free Trade Agreement between South Africa and the European Union. The results reported in Table 2.15 indicate that a 1% change in beef price, following a FTA between SA and the EU, would have a relatively greater impact on the consumption of other meats than would 1% changes in chicken, mutton or pork prices. For example, a 1% fall in beef price would cause chicken consumption to fall by 0.43%, while a 1% fall in chicken price would reduce beef consumption by only 0.14% (Badurally-Adam, 1998).

Table 2.16: Conditional income and Slutsky elasticity estimates of South African meats: 1971 - 1996

	Conditional income elasticity	Conditional Slutsky elasticity estimates with respect to the price of			
		Beef	Chicken	Mutton	Pork
Beef	1.17	-0.42	0.12	0.23	0.06
Chicken	0.40	0.37	-0.32	-0.01	0.04
Mutton	1.37	0.79	-0.01	-0.80	0.02
Pork	0.53	0.48	-0.1	0.05	-0.43

Source: Badurally Adam (1998)

2.8.3 Price leadership

Van Zyl, Van Heerden, Groenewald and Vivier (1992), quantified price interactions and price leadership among meat products and eggs in South Africa by means of the Haugh-Pierce Chi-squared causality test. Their results indicated a weak relationship between eggs and various types of meat (beef, mutton, pork, chicken and fish). This weak relationship indicates that price changes in the meat market **do not affect** the demand for eggs. Neither do changes in egg prices exert any discernable effect on meat prices (Van Zyl *et al....*, 1992).

A particular high mutual dependence was found between beef, mutton, pork and chicken prices. In a further test, beef was found to be the price leader in the meat market with respect to chicken, pork, and mutton. In short, the long-term multiplier effects, as calculated from multivariate AR(p) models, indicate the following (Van Zyl *et al.*, 1992):

- A 1 cent change in the price of **beef** will result in a change of 0.75, 1.21, 2.34 and 1.20 cents in the price of mutton, pork, chicken and fish respectively. In the case of mutton, this effect will take approximately 8 weeks to filter through, whereas in the case of the other three product, a 12 week filtering period is expected.
- In the case of **mutton,** on the other hand, a 1 cent change in the price of mutton will result in a change of 2 cents in the price of fish, which will take approximately 12 weeks to filter through. Similarly the multiplier effect indicates that a 1 cent change in the price of fish will lead to a 0.47 cent change in the price of mutton after 12 weeks.
- **Chicken was** found to be the price leader with respect to pork and fish prices, and the long-term multiplier effect indicated that a 1 cent price change of chicken will result in a 0.574 cent and 0.565 cent change in the price of pork and fish respectively. In both cases the a 12 week filtering period is also expected.

Van Zyl *et al.* (1992) also noted that their findings correspond with those of Du Toit (1982) and Hancock *et al.* (1984), which were covered in the previous section, in the sense that both other authors also identified significant cross-elasticities in respect of beef and mutton and beef and pork.

2.9 Two alternative econometric methodologies

Nowadays there is reasonable contrast between the methodology currently being used for econometric analysis, and what used to be commonly associated with econometric modelling. During the last two decades, the emphasis of econometric modelling has basically shifted from the model to the data and data characteristics. As it will become clear in this section, this means that, with new methodologies, the data and its characteristics fulfil a much more central role in the analysis than in the traditional methodology.

Perhaps the most important difference between the traditional and the new methodologies is that the new methodology distinguishes explicitly between long and short-run equilibrium characteristics, and further between the equilibrium and the disequilibruim behaviour of the system, which is absent in the traditional approach (Fedderke, 2000).

2.9.1 The traditional econometric view

Traditionally, econometric methodology started of with economic hypotheses, and then the data was subjected to empirical testing in order to accept or reject the theory. As shown in Figure 2.1 below, the acceptance of the theory leads to the use of the model in terms of understanding, prediction and policy formulation or analysis. As soon as the hypothesis is rejected, econometricians return to the original theory to try and formulate new hypotheses, which leads to the whole process being repeated.

From Figure 2.4 it becomes clear that the data is regarded as exogenous to the entire process, meaning that the data is introduced into the modelling process from outside in order to establish the validity of the model.

With traditional methodology, a "specific-to-general" approach was normally used to separate the long-run characteristics from the short-run characteristics. This "specific-to-general" approach can better be described in a way that the dynamics were added to the long-run specification in a relatively ad-hoc manner. Sometimes, what tends to happen, is that the long and short-run dynamics become confused and mingled (Fedderke, 2000).

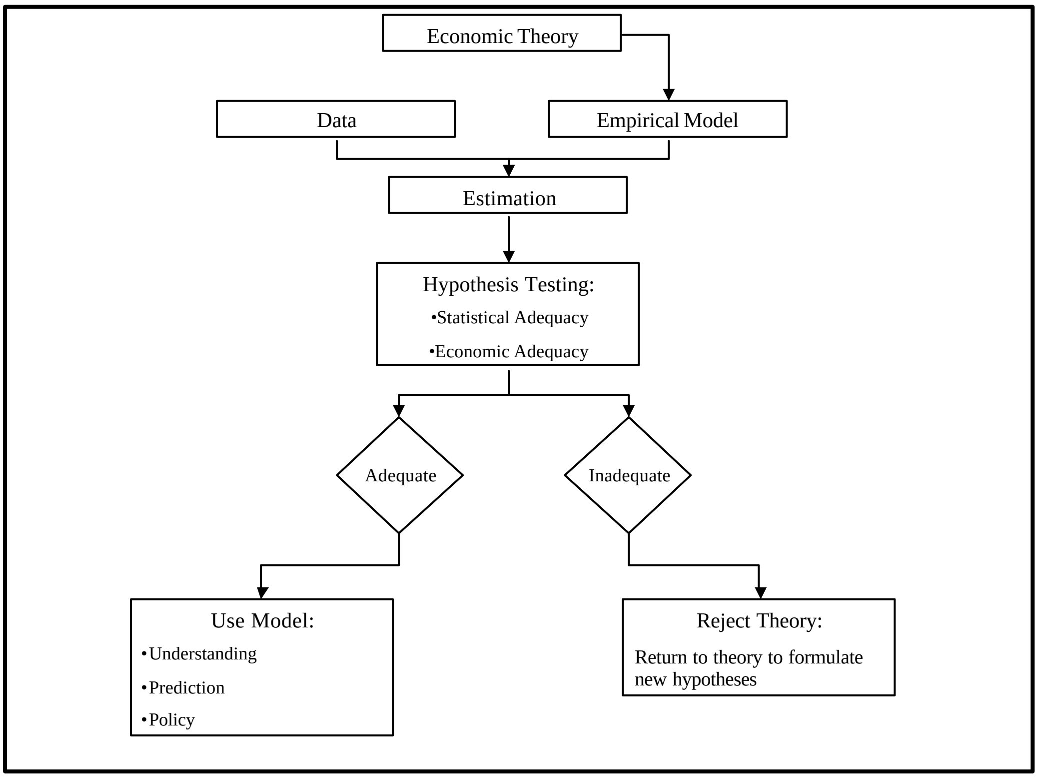

Figure 2.4: Schematic representation of the traditional econometric methodology

Source: Pauly (1997)

2.9.2 The "new" econometric methodology

In the case of the "new" econometric methodology, the data and its characteristics fulfil a central role. The new methodology, as illustrated in Figure 2.5, starts out by testing the dynamics of the data employed for the purposes of estimation.

The dynamics of time series data can be characterized as stationary or non-stationary. Studenmund (2001) formally defined a time-series variable, X_t as stationary when the mean and variance of X_t are constant over time and the autocorrelation function between X_t and X_{t-1} depends on the lag length. If one or more of these three properties are not met, the X_t is non-stationary.

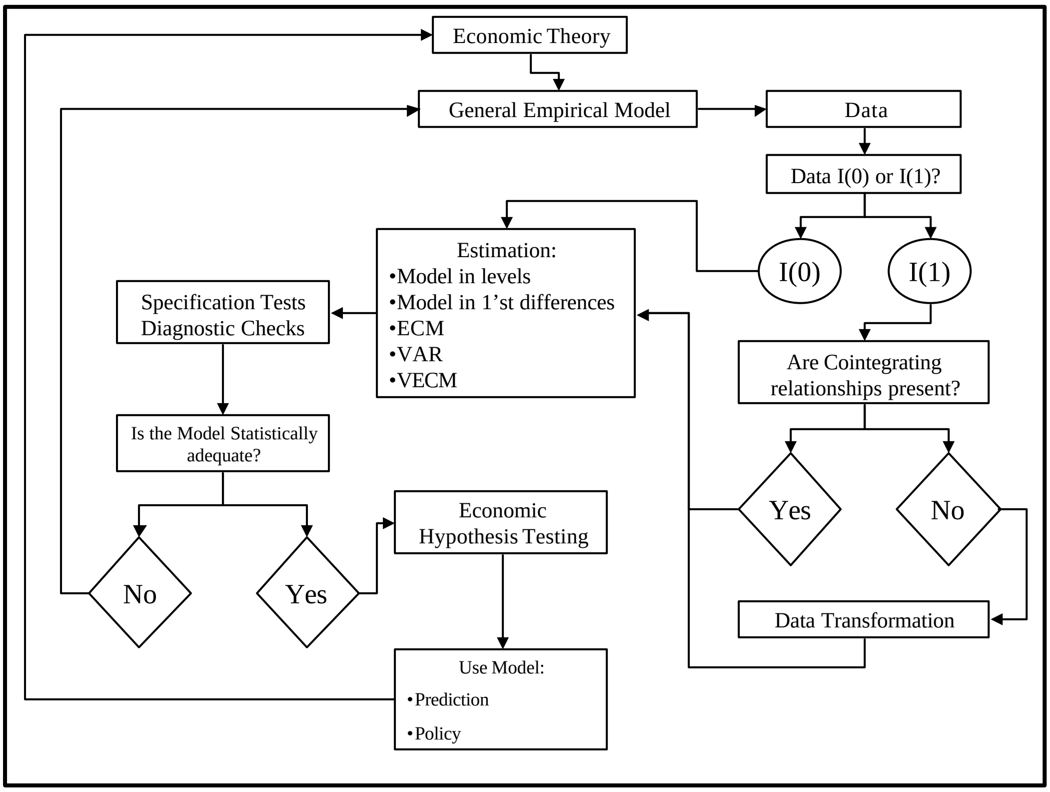

Figure 2.5: Schematic representation of the new econometric methodology
Source: Pauly (1997)

When normal regression analysis is conducted with non-stationary data, a spurious regression may be the result. In a spurious regression two or more independent variables are spuriously correlated. A spurious regression violates the basic assumptions of Ordinary Least Squares (OLS), thus the OLS parameters are no longer BLUE (Best, Linear Unbiased Estimate), meaning that the t-scores and the overall fit of such a spurious regression are likely to be overstated and untrustworthy.

As discussed in section 2.3, demand models are restricted to be homogeneous of degree zero in prices. Ng's (1995) findings, based on empirical estimations of demand systems, repeatedly rejected the homogeneity restriction. However, Ng further pointed out that the hypothesis is often formulated in terms of regressors that are non-stationary, and suggests that time series issues are partly responsible for rejections. By making use of recently developed techniques for estimating cointegrating vectors, Ng, showed that the homogeneity restriction holds in many cases.

Determining the stationary characteristics of the data will thus determine the econometric technique that will be used for the empirical estimation. Under stationary data, I(0), standard OLS techniques are likely to be legitimate. For non-stationary data (integrated to the order one or higher), alternative estimation techniques like cointegration, for example, is imperative for legitimate results. As discussed earlier, when standard estimation techniques are applied to higher order integrated data, strong and statistically robust relationships that are spurious might be detected. With spurious regressions, the standard diagnostic tests such as t-statistics, F-tests and R^2 statistics become completely unreliable and will detect the presence of a relationship where there is none.

New estimation techniques, like cointegration, first establish whether the characteristics of the data are consistent with the presence of a long-run equilibrium relationship between the variables theory (Fedderke, 2000). Cointegration techniques basically rely on diagnostic tests that are totally independent of the standard t-, F-, R^2 statistics. Where the data are cointegrated, it might be true that a long run economic relationship does exist, since cointegration is a necessary but NOT sufficient condition for a long-run economic relationship to be present.

With cointegration present in a data set, one can proceed by a number of alternative estimation techniques to determine the equilibrium relationship. On the other hand, in the absence of cointegration, there is strong evidence to believe a long-run relationship does not exit. Moreover, from Figure 2.2 it further becomes clear that the transformation of the data might render the series cointegrated. Effectively, this new methodology allows for greater interaction between the data and theoretical models (Fedderke, 2000).

In contrast with the traditional methodology, where the long and short-run dynamics tend to mingle, this new methodology effectively separates the two. As soon as the long and short-run dynamics are separated, Error Correction Models (ECM) allow one to represent the combined specification of the long and short-run models and to make more accurate inferences regarding the relationship.

2.10 Critique against earlier South African demand studies

Critique against demand relations estimates previously conducted in South Africa is mainly threefold. **Firstly**, the functional forms used in most studies, doesn't adhere to micro-economic theory, i.e. the demand relations does not include the restrictions of adding-up, homogeneity and symmetry. This is clear from the fact that the bulk of the studies utilize single equation techniques, and not one of the "systems of equations" approaches developed during the last two decades.

Secondly, earlier studies didn't analyse the characteristics of the data used. As explained in the previous section, analysing the characteristic of the data prior to estimation is very important, firstly to improve the reliability of the estimated parameters and secondly to be able to distinguish between the long- and short-run dynamics.

Thirdly, the majority of the South African demand studies reviewed date back to the mid and late 1980s, as noted earlier. It is important to remember that the marketing of these meat products was controlled to some extent until as late as 1997. It is thus not to far fetched to expect a change in the demand relations since the start of the deregulation process.

2.11 Conclusion

This chapter started by giving an overview of basic demand theory and the properties thereof. In a discussion of various demand model specifications, it became clear that single equation techniques as previously used in a South African context to analyze meat demand, pose major limitations. These shortcomings, criticized in the previous section of this chapter, are further complicated by more recent developments in econometrics.

A review of literature on both international and local meat demand relations, proved that the demand for meat products changes over time as tastes and preference of consumers develop. It seems likely that a more inalienable factor of the demand relations of meat is the specification of the demand model utilized in the estimation process. From the literature it became clear that two models gained prominence in agricultural economics during the last two decades, namely the Rotterdam and AIDS specifications. For this reason, it was decided to apply both models to South African meat data, and then to choose the superior one based on the empirical results.

CHAPTER **3**

INDUSTRY OVERVIEW AND DATA PROPERTIES

3.1 Introduction

The South African red meat industry was, and will in the future remain, one of the most important agricultural sub-sectors in South Africa. This can be attributed largely to natural circumstances as, approximately 70 per cent of South Africa's total area of 1.2 million km^2 is only suitable for livestock production.

The red meat industry evolved from a highly regulated environment to one that is totally deregulated today. Various policies, such as the distinction between controlled and uncontrolled areas, compulsory levies payable by producers, restrictions on the creation of abattoirs, the compulsory auctioning of carcasses according to grade and mass in controlled areas, supply control via permits and quotas, the setting of floor prices and the floor price removal scheme, etc. characterized the red meat industry before deregulation commenced in the early 1990s (Jooste, 1996). The final nail in the coffin of the regulated red meat market came in 1997, when all control boards were abolished. Since then the red meat industry has experienced several structural changes, e.g. an increasing number of animals being fattend in feedlots and the mushrooming of abattoirs in the previously uncontrolled areas.

This chapter consists of two parts, firstly an overview of the South African red meat industry is presented, broken down into production, consumption, expenditure and prices of beef, pork and mutton. Secondly, a description of the time series properties of the data employed in the study are handled in four parts, namely; tests on the univariate properties of the data, structural breaks, seperability and exogeneity of the expenditure variable.

3.2 Production of red meat in South Africa

- **The beef sector**

Figure 3.1 shows the South African cattle herd and the number of animals slaughtered annually since 1973. The commercial cattle herd comprises of approximately 65 per cent of the total cattle herd. This means that approximately 35 per cent of all cattle in South Africa are owned by non-commercial farmers. Sixty-eight per cent of the commercial herd comprises of female animals, of which the majority is for meat production. The composition of the national herd is not expected to change significantly in the future. The main feature depicted in Figure 3.1 is the cyclical trend in herd numbers. Lubbe (1990) states that the cyclical behaviour of beef supply is attributable largely to cyclical behaviour of female slaughterings.

The main contributor to this phenomenon is climatic conditions. The correlation between national herd numbers and the three-year moving average of rainfall was estimated at 0,62 by the Sunnyside Group (1991). Lubbe (1990) investigated the decomposition of price time series components in the red meat industry. He states that the combined effect of rainfall, the variation in production capacity and price expectations produce an environment for relatively unstable prices. Furthermore, livestock expansion and liquidation processes are fueled by the rainfall cycle and rainfall expectations. Lubbe (1990) concluded that agricultural policy and farmers' strategies could be more effective if the existence and nature of price and rainfall cycles are known.

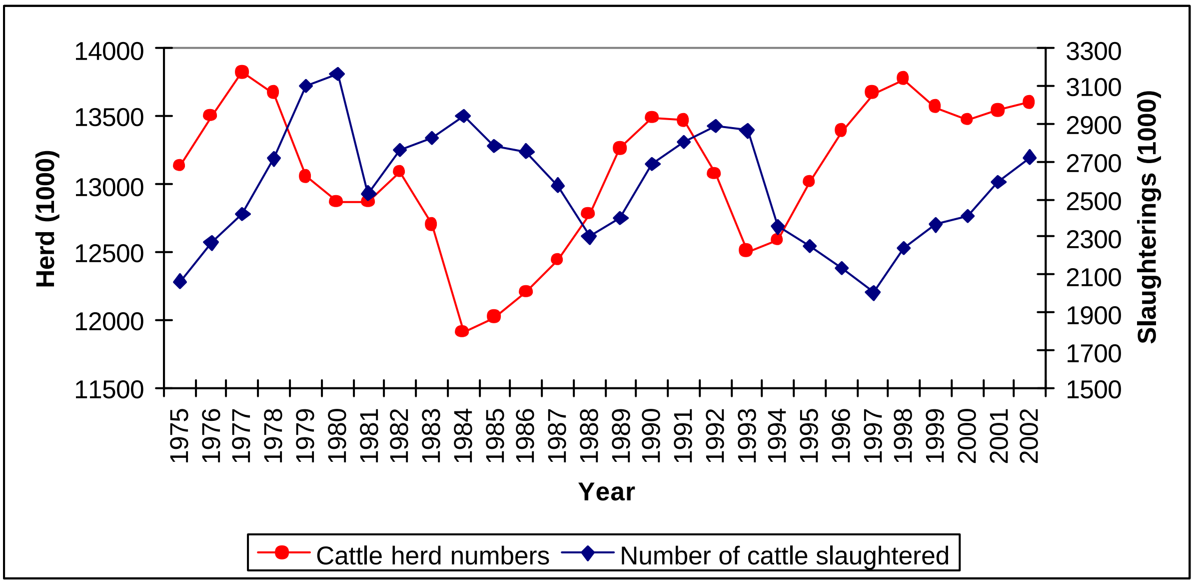

Figure 3.1: The South African cattle herd and slaughtering (1975 - 2002)

Source: Agrimark Trends, 2003; NDA, 2003.

Since the deregulation process in the red meat industry started in 1992 there has been a marked increase in the number of cattle slaughtered in previously non-controlled areas. Before deregulation the slaughtering of red meat was demarcated into controlled and uncontrolled areas. In other words, red meat producers in the uncontrolled areas were not allowed to slaughter animals in uncontrolled areas and then sell the meat in controlled areas. They were, however, allowed to transport the live animals to the controlled areas for slaughtering, after which the meat could be sold there. According to Venter (1996) this means that the beef industry has moved to a marketing system aimed at reducing the direct and indirect costs of marketing (direct costs include transport and other transaction costs, as well as social costs, whilst indirect costs include issues such as weight loss and death). The result of this state of affairs is that direct marketing and the number of animals slaughtered in primary production areas has increased at the expense of carcass auctions in large metropolis. Venter (1996) also states that this phenomenon is not unique to South Africa, and cites Tomek and Robinson (1990) who described a similar situation for the US.

- **The pork sector**

Figure 3.2 shows the relation between the number of commercial pigs slaughtered and the domestic pig herd. The growth in terms of the pig herd and the number of animals slaughtered can be attributed largely to large investments in this industry, e.g. computerised feeding and environmental maintenance equipment, better disease control by improving the housing environment, etc., that contributed to improved production circumstances and efficiency.

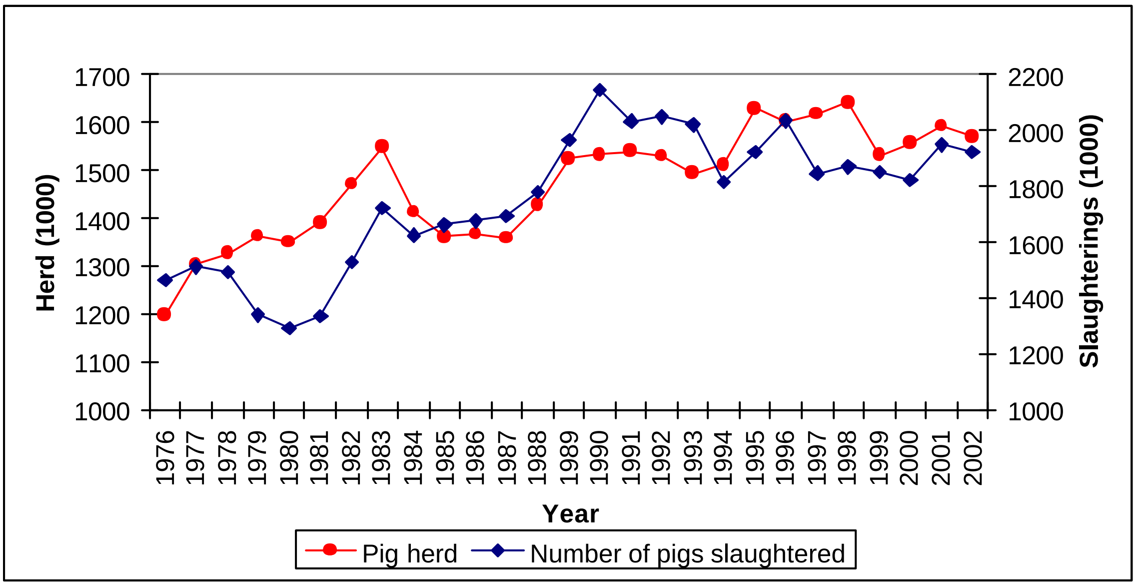

Figure 3.2: The South African pig herd and slaughtering (1976 - 2001)

Source: Agrimark Trends, 2003; NDA, 2003.

- **The sheep industry**

Figure 3.3 shows the South African sheep flock and the number of sheep slaughtered. Sheep numbers started to drop quite drastically during the mid 1980s, mainly due to a collapse of the wool industry, but recovered well up to 1990, whereafter it dropped again and stabilized at around 29 million animals. Similarly, sheep meat production dropped to an all-time low in the mid 1990s. The main reasons for this phenomenon can be traced back to the following:

- Severe drought in the early nineties;

- escalation of stock theft; and
- the breakdown of vermin control.

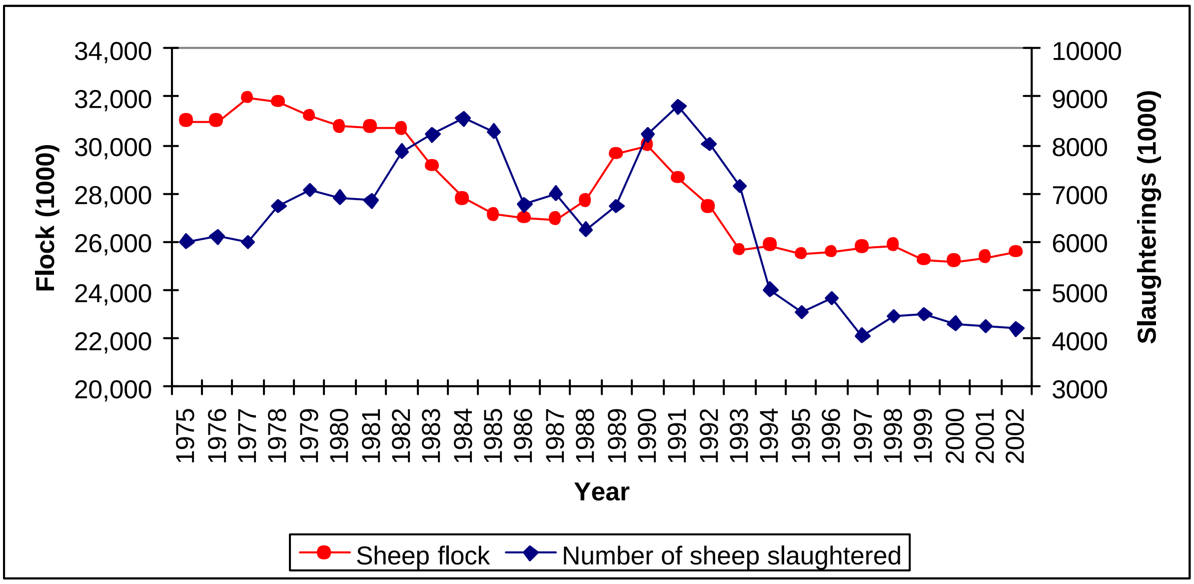

Figure 3.3: The South African sheep flock and slaughterings (1976 - 2001)

Source: Agrimark Trends, 2003.

Since the start of the deregulation process in 1985, a healthy informal market has been created, with its own distribution network. Today approximately 1,6 million sheep are marketed in the informal market, increasing at approximately 2 per cent per annum. For example, Karaan and Myburgh (1992) report that the marketing of sheep in Western Cape townships has increased tremendously and has developed its own marketing distribution system. However, this system is not without its problems, e.g. there are sporadic shortages of sheep, a relatively low degree of competition, high risk and concerns about health and hygiene hazards. Despite these problems it appears as if entrepreneurs in this market segment are able to exploit the opportunities that exist. In fact, there are important lessons to be learned from the study by Karaan and Myburgh (1992), i.e. sheep that used to grade badly in the formal marketing channels are highly sought after in the townships. They state that it is ironic that low-graded sheep meat attain much higher prices than the better graded sheep/carcasses at the auctions, but that retailing to consumers takes place at lower prices than formal prices on average. This can be attributed to lower cost of distribution and lower opportunity cost of labour, whilst at the same time these entrepreneurs succeed in providing constant form, place, time and possession utilities that consumers in this market segment require.

3.3 Consumption of red meat in South Africa

- **The beef sector**

The per capita consumption of beef has come under increased pressure since the early 1990s. This can be attributed mainly to a decreasing or stagnating per capita disposable income and the price advantage that poultry has over beef. Figure 3.4 shows the relation between real per capita disposable income and the per capita consumption of beef. It is clear that per capita disposable income and beef consumption are very closely linked. This is emphasized by the fact that beef has a high income-elasticity of demand (Nieuwoudt, 1998).

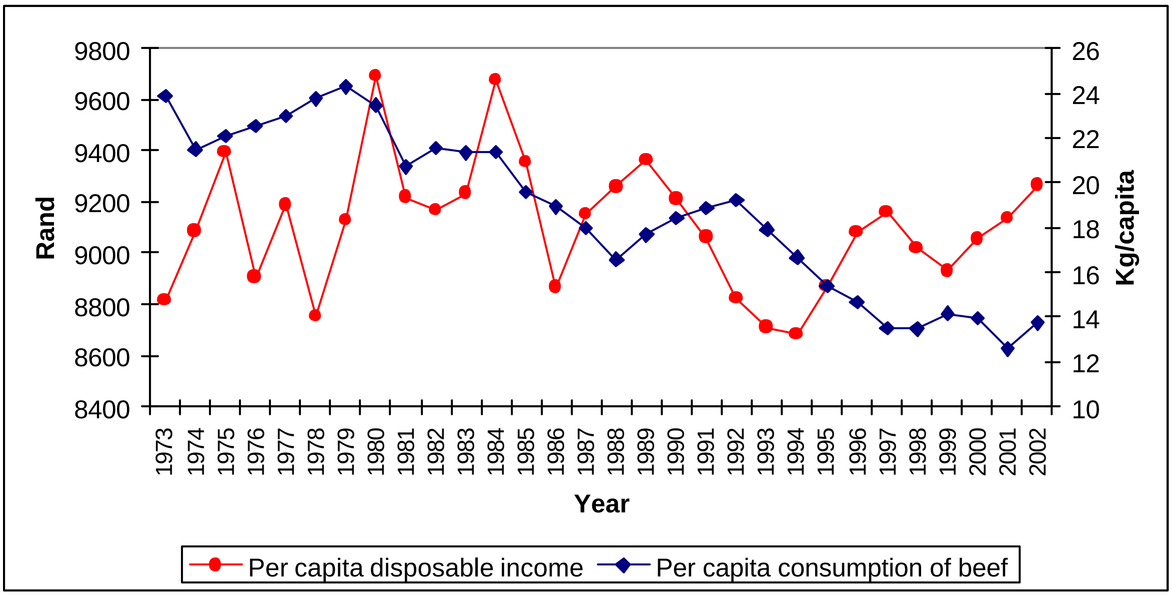

Figure 3.4: Relation between real per capita disposable income and the per capita consumption of beef (1973 - 2002)

Source: SARB, 2003; NDA, 2003; own calculations.

Nieuwoudt (1998) suggests that the expected racial mix of the South African population has important implications for food demand. For instance as the Black population growth rate is higher than the rates of the other groups, the average per capita food consumption of all groups taken together may decline over time, though the per capita growth rate of each group may increase. The reason for this phe nomenon, as suggested by Nieuwoudt (1998), is that the group with the highest population growth often has the lowest per capita demand consumption of livestock products.

Nieuwoudt (1998), by considering (i) population growth rate, (ii) income elasticity, (iii) economic growth rate and (iv) urbanization, estimated the demand for various livestock products under different economic growth scenarios until 2020/2021 (for a detailed description of the analytical framework see Nieuwoudt (1998)). Taking a short-term view the expected increase in the demand for beef under a 3 per cent economic growth rate and a low income scenario could range between 12 and 25 per cent for 2000/2001, with 1995 as basis. Estimations for a 5 per cent economic growth rate were also made, but given the state of the world economy, and specifically the South African economy, such a growth rate is not foreseen. In fact, even when taking an optimistic view, a 3 per cent economic growth rate over the next few years is unlikely. Given this assumption, per capita demand for beef is expected to remain relatively constant or even to decline in the foreseeable future.

- **The pork sector**

The per capita consumption of pork has been moving sideways over the last couple of decades. This is contrary to the trend with regard to per capita beef and mutton consumption. As is the case worldwide, pork and poultry serve primarily as substitutes for beef. In certain instances pork is regarded as the other white meat. Although a misconception, it proves to be to the benefit of pork producers. Figure 3.5 shows the relation between real per capita disposable income and the per capita consumption of pork.

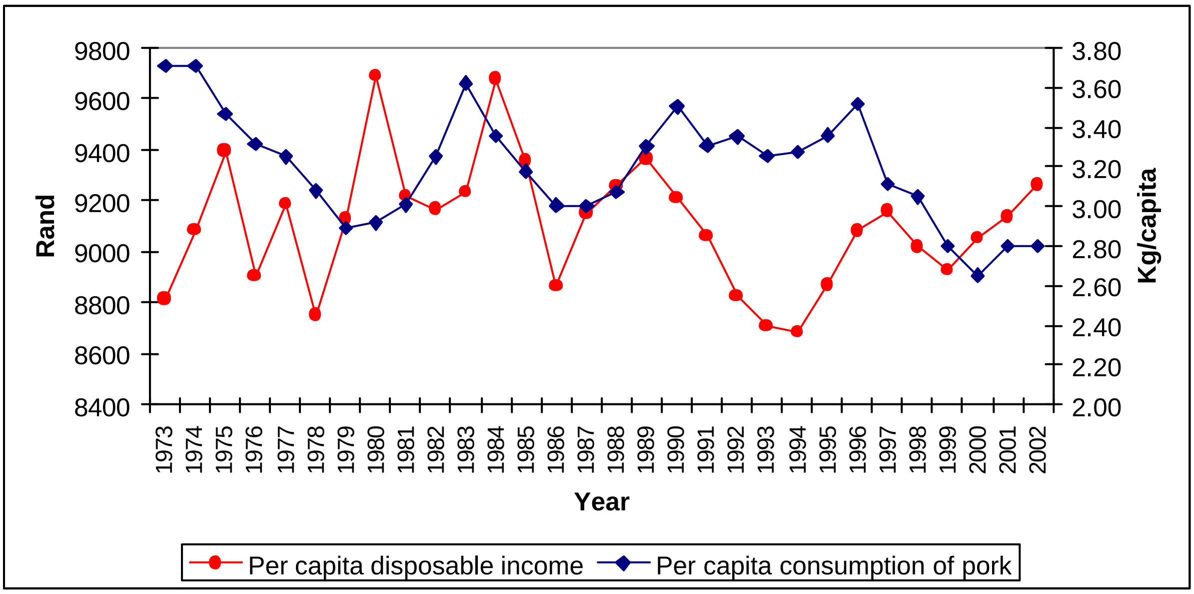

Figure 3.5: Relation between real per capita disposable income and the per capita consumption of pork (1973 - 2002)

Source: SARB, 2003; NDA, 2003.

Nieuwoudt (1998) states that the income elasticity of pork is relatively low compared to other red meat products. This means that when per capita disposable income increases, consumers will purchase, in relative terms, more other red meat products, and vice versa. Nieuwoudt (1998) expects that under a 3 per cent economic growth and a low income scenario, the demand for pork will increase between 8 and 12 per cent for 2000/2001, with 1995 as basis. The reason is that pork is consumed mainly by whites, who under an income growth scenario of 3 per cent will have the lowest increase in per capita income.

- **The sheep sector**

South Africa is only able to supply approximately 80 per cent of the local demand for sheep meat. Shortages in the domestic market are supplemented by imports, mostly from Namibia (live animals) and Australia. As with the other red meats, especially beef, sheep meat consumption is highly sensitive to changes in per capita income. Figure 3.6 illustrates the correlation between per capita consumption of sheep meat and the per capita income of people in South Africa. According to Nieuwoudt (1998), the expected increase in the demand for sheep meat under a 3 per cent growth in the economy and low income scenarios could range between 12 and 25 per cent for 2000/2001, with 1995 as basis.

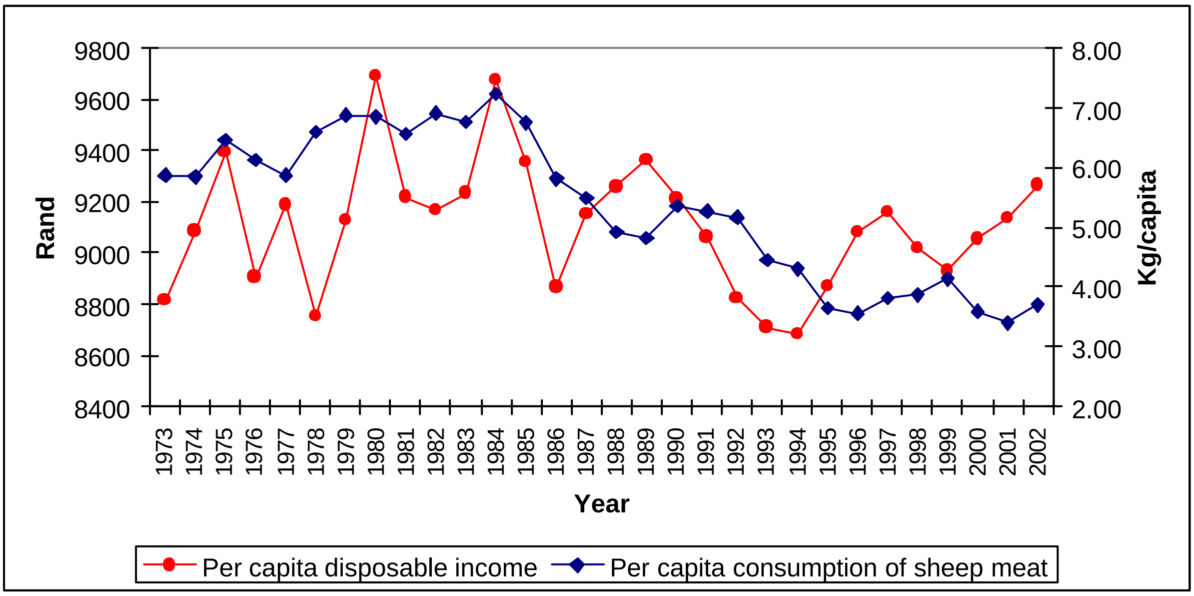

Figure 3.6: Relation between real per capita disposable income and the per capita consumption of sheep meat (1973 - 2002)

Source: SARB, 2003; NDA, 2003.

3.4 Expenditure on red meat

It is clearly shown that the current South African real per capita disposable income is, in relative terms equal to that of the early 1970s. According to Jooste (2001), this stagnating real per capita disposable income, together with the relative price advantage that poultry has over beef, can be the major reason why the per capita consumption of red meat (beef, pork and mutton) has come under increased pressure. The opposite seems to apply when the per capita consumption of chicken is considered.

Figure 3.7 presents the total expenditure shares of five protein sources (beef, chicken, pork, mutton and eggs) for South Africa from 1970 to 2000. From Figure 3.7 it is clear that, of the five products, total expenditure on beef and mutton showed the largest decrease. Total expenditure on pork decreased slightly over the last 30 years, whereas the total expenditure on chicken and eggs experienced the largest and second largest increase respectively.

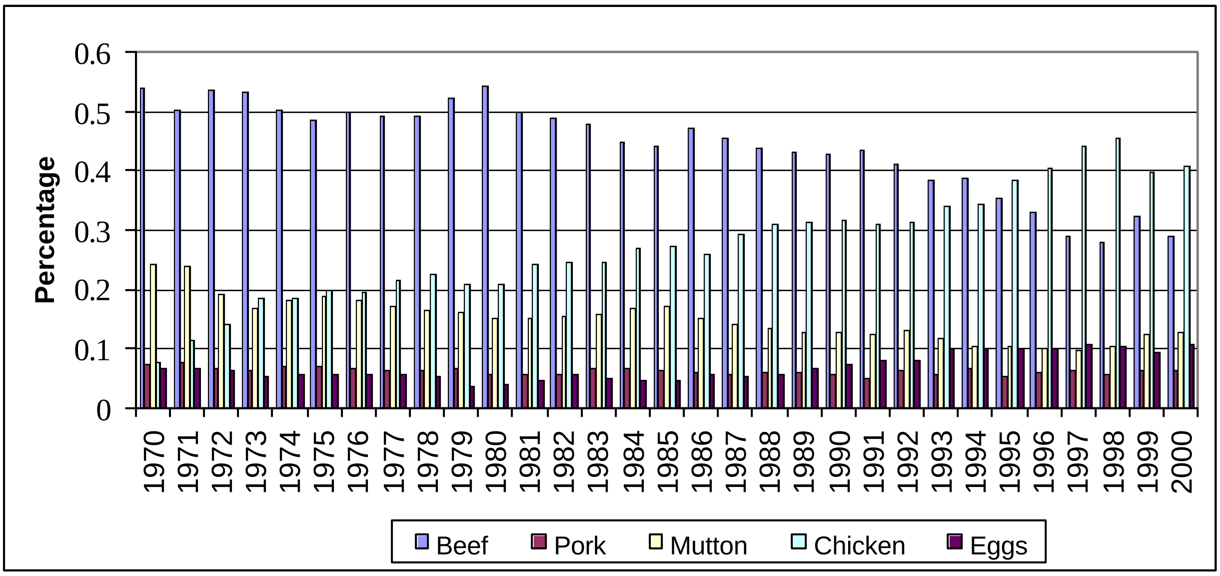

Figure 3.7: Total expenditure shares of beef, chicken, pork, mutton and eggs (1970 – 2000)
Source: NDA, 2003 and own calculations

Table 3.1 shows the real per capita expenditure on red meats for 1993 and 1999. The methodology used to calculate the real per capita expenditure on red meats is similar to that used by Nieuwoudt (1998). Nieuwoudt used a system of two equations to estimate rural and urban per capita expenditure per population group (see Nieuwoudt 1998 for the methodology used).

Table 3.1 shows that real per capita expenditure for beef, pork and sheep meat has declined since 1993. The largest decline in per capita expenditure was experienced by beef, followed by sheep meat and then pork. In terms of the total population, per capita expenditure on beef is still the highest. Whites spend the most on beef, followed by blacks in urban areas, but it is important to note that real per capita expenditure by both declined considerably between 1993 and 1999. In the case of sheep meat, asians spend the most, followed by whites and then coloureds. Also note the decline in real per capita expenditure by especially whites and asians. Real per capita expenditure on pork is dominated by whites, followed distantly by the other population groups. Interesting to note is the increase in the per capita expenditure of blacks in rural areas for all three red meats. This could probably be attributed to increases in real income from a very low base.

Table 3.1: Real per capita expenditure on red meat in South Africa

Population group	Beef		Sheep meat		Pork	
	Rand per capita (1993 = base period)					
	1993	**1999**	**1993**	**1999**	**1993**	**1999**
Asians	179.73	115.47	396.20	280.80	17.81	25.14
Blacks (urban)	223.00	136.45	65.48	53.12	18.25	19.95
Blacks (rural)	53.57	71.85	15.73	27.97	4.38	10.51
Coloureds	203.55	105.58	158.19	144.69	33.45	29.23
Whites	540.30	325.34	303.56	245.00	139.91	120.04
Total population	187.53	127.38	91.29	77.33	29.35	27.74

Source: NDA, 2001.

3.4 Prices of red meat

- **The beef sector**

Figure 3.7 shows the relation between the real beef producer price and per capita consumption of beef. It is important to note that the real producer prices and per capita consumption of beef are, too a large degree, mirror images. What is, however, of concern is the general downward trend in both variables, as shown in Figure 3.8. The reasons for this is, firstly, the pressure on per capita disposable income which renders consumers unable to react to more favourable prices, secondly, the beef to poultry price ratio that favours poultry and, thirdly, the influence of non-economic factors such as product consistency and quality, food safety, health and nutrition concerns, and convenience.

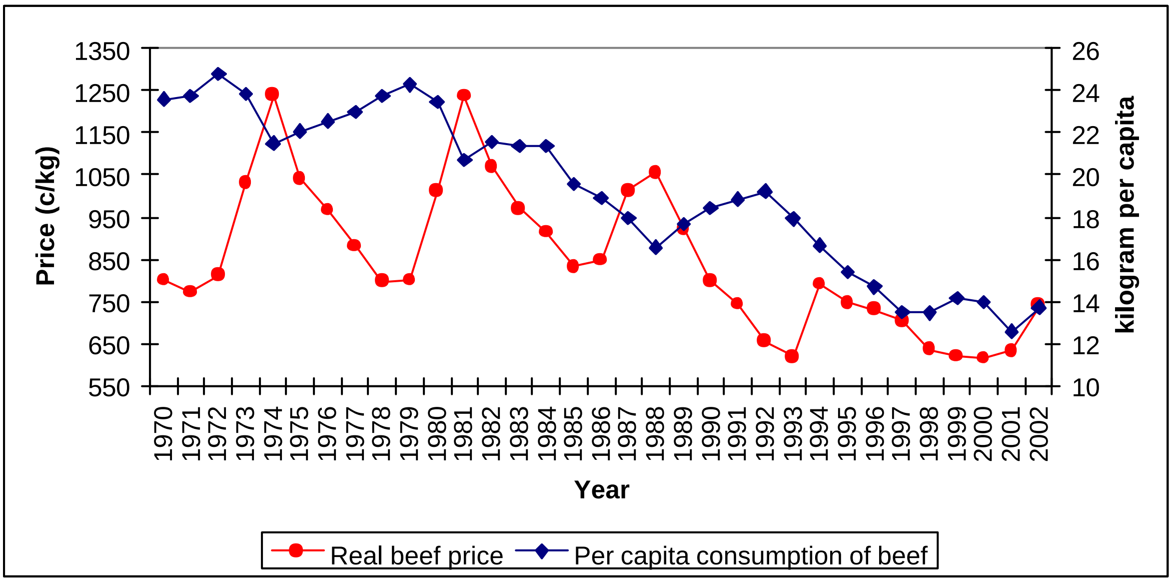

Figure 3.8: The relation between the real average auction price of beef and per capita consumption of beef (1970 - 2002)

Source: NDA, 2003; Agrimark Trends, 2003.

- **The pork sector**

Figure 3.9 shows the relation between the pork producer price and per capita consumption of pork. Relatively stable per capita consumption of pork, improved efficiency and the ability of producers to react more swiftly to market conditions than other red meat producers, are probably the reasons for real prices of pork not showing a similar downward trend to that of beef.

Lubbe (1992a) states that the effects of marketing arrangements applied to red meat during the control board era were weaker than of beef and sheep due to the relatively low volumes of pork marketed via the controlled markets. This implies that the substitution of red meat for poultry due to the inability of the red meat marketing scheme to adjust to changes in the socio-economic environment was not as severe in the pork industry as it was in the beef and sheep industries. The significance of this state of affairs lies in the fact that, according to Schiffman and Kanuk (1987) and Kotler (1988), consumers' tastes and preferences change slowly over time. Uys (1986) states that these preferences consist of utility and memory components.

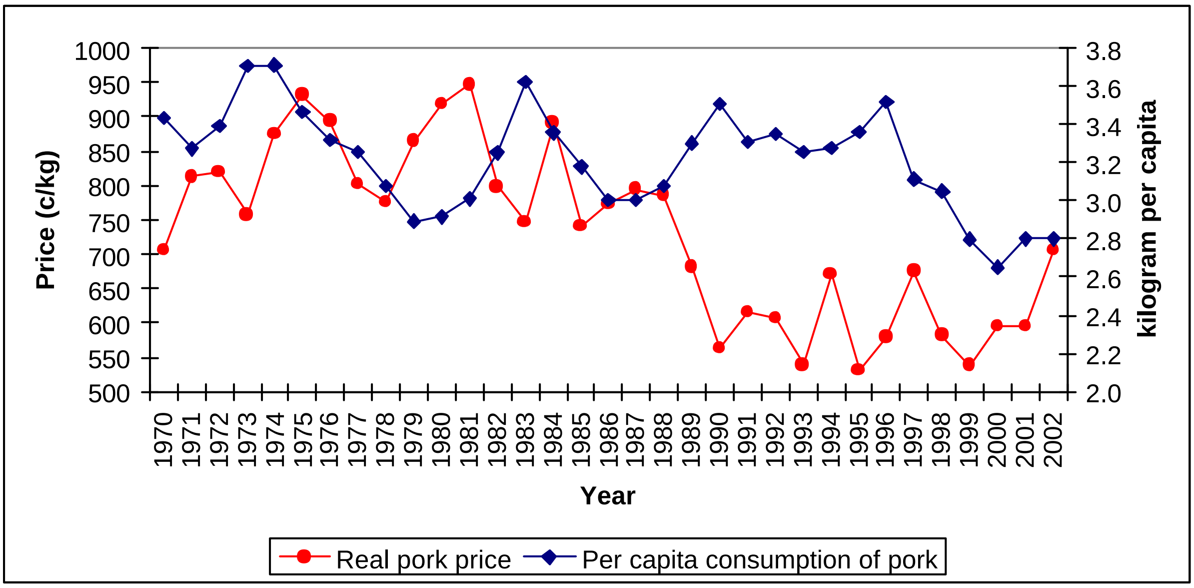

Figure 3.9: The relation between the real average auction price of pork and per capita consumption of pork (1970 - 2002)

Source: NDA, 2003; Agrimark Trends, 2003.

Utility is on the one hand, the rational behaviour or reaction to income and prices, whilst on the other hand, the memory component is a continuation of the influences of past reasons for reaction to the utility component in current or future decisions. In other words, although consumers' buying behaviour will still be influenced by price and income variables, development of consumption patterns over time will also to a large extent influence current buying behaviour. Thus, one could conclude that the less significant impact of the red meat marketing scheme on the pork industry in the past is one of the reasons why this industry performs better today than beef and sheep do as far as per capita consumption is concerned. In fact, Lubbe (1992) states that, had pork not been regulated or restricted by the same regulations, the controlled marketing practices and policies of beef and mutton would have stimulated from the demand for pork.

- **The sheep industry**

Figure 3.10 shows the relation between the per capita consumption of sheep meat and the real producer price of sheep. It is clear that whenever real prices go down, consumption tends to increase. Also note that per capita consumption and real prices both show a declining trend. In other words, although sheep meat should be cheaper from a consumer point of view, consumers prefer to substitute sheep for other commodities. The reason for this state of affairs may be the fact that sheep meat is considerably more expensive than other red meats and poultry. Hence, although real prices have declined, the price wedge between other products and sheep meat is still limiting consumption. Although this is not only a South African phenomenon, the domestic sheep industry will have to consider strategies to reverse the current situation. Neglecting to do so will cost this industry dearly.

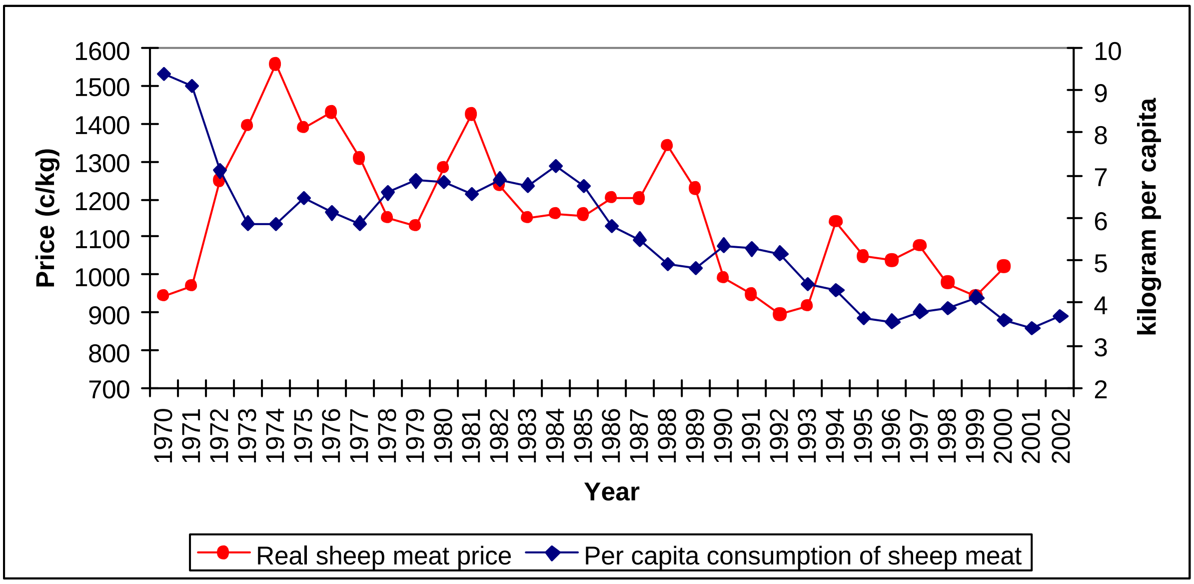

Figure 3.10: The relation between the real average auction price of sheep meat and per capita consumption of sheep meat (1970 - 2002)

Source: NDA, 2003; Agrimark Trends, 2003.

3.5 Data properties

As explained in the previous chapter, the data to be used must be analysed and tested in three ways before a demand model can be estimated. The first set of tests is based on the statistical properties of the variables included in the demand model. Secondly, as explained in section 2.3, the products included in the demand model must be separable. Separability among meat and eggs, as main sources of protein, is tested by means of F and Likelihood Ratio (LR) tests.

Finally, in order to use a Seemingly Unrelated Regression procedure, the expenditure variable calculated must be exogenous. The Hausman test for exogeneity was used to determine this.

3.5.1 Tests on the statistical properties of the variables

3.5.1.1 Univariate properties of the data

From the previous chapter it is clear that according to "modern" econometric methodology, the data and its characteristics fulfil a central role. Models that contain non-stationary variables will often result in spurious regression, i.e. indicating the existence of statistically significant relationships where there are none. Thus, in order to apply appropriate time series estimation techniques successfully, it is of utmost importance to understand the univariate properties of the data (Fedderke, 2000).

A central assumption of the classical normal linear regression model is that the observations are independently sampled, thus a stochastic process. In the case of economic time series data, this assumption is generally violated often, by the fact that observations are connected in all kinds of ways, such as inflation. Fedderke (2000) defines a stationary process by the fact that the distribution of the random error term must be the same throughout the whole distribution, i.e. constant mean and constant variance. Intuitively, time should not matter in a stationary process. Any series that contains a long-term trend is by definition non-stationary.

It is thus clear that each time series variable to be employed in a model must be tested for its time series characteristics, i.e. whether it is stationary or not. Where a series is non-stationary, the number of times it must be differenced in order to render the series stationary is important. Various tests exist for testing for the univariate characteristics of a series, namely the autocorrelation function, the spectral density function, the Perron test, the Phillips-Perron test, and the Dickey-Fuller (DF) test, to name only a few. The test that is applied in this study is the DF and an extension thereof called the Augmented Dickey-Fuller (ADF).

Variants of each other, the DF and ADF are the most commonly used tests for the presence of a unit root. According to Fedderke (2000), their popularity rests on their generality as well as their simplicity.

Table 3.2 below reports DF and ADF(1) test statistics for all the variables to be employed in the analysis done in the following chapters. Two kinds of stationarity tests are conducted throughout, i.e. whether the series is mean stationary, or mean and trend stationary. The table basically consist of two parts, the first five columns report the test statistics for the variables in levels, whereas the latter five columns reports the test statistics for the variables in 1st differenced format. In both cases, the variables are tested for mean, or mean and trend stationary. The last row of the table reports the 95% critical value. The following hypothesis can be tested for each variable:

H_0: The series is stationary

H_1: The series is non-stationary

If the calculated statistic is smaller than the critical value, H_0 is not rejected and the series is assumed to be stationary. On the other hand, if the calculated statistic is larger than the critical value, H_0 is rejected and it can be accepted that the series is non-stationary. From Table 3.2 it is clear that the variables to be employed in the LA/AIDS model are all integrated of the order 1, I(1), i.e. stationary in the first difference form.

Table 3.2: Test statistic for unit roots in variables

Variables in levels	Intercept		Intercept and trend		Variables in 1st difference form	Intercept		Intercept and trend	
	DF	ADF(1)	DF	ADF(1)		DF	ADF(1)	DF	ADF(1)
BW	0.01889	0.05104	-2.143	-2.2097	**DBW**	-4.976	-4.696	-5.1383	-5.2077
CW	-0.4606	-0.4117	-2.5388	-2.6334	**DCW**	-5.0751	-4.081	-4.9736	-4.1033
PW	-4.1175	-2.983	-3.8866	-2.6996	**DPW**	-7.6376	-4.6416	-7.8011	-4.7836
MW	-1.5675	-2.0347	-1.1506	-2.9028	**DMW**	-3.5861	-3.6322	-3.8823	-3.7212
lnbp	-1.1558	-1.1199	-1.3449	-1.9665	**dlnbp**	-4.0733	-3.7674	-4.2084	-3.9742
lncp	-1.4719	-1.3953	-0.5444	-1.9141	**dlncp**	-3.5195	-3.9522	-3.8659	-4.2184
lnpp	-0.5068	-0.6145	-3.2238	-2.932	**dlnpp**	-6.0407	-5.5348	-5.9216	-5.4996
lnmp	-0.04	-0.0581	-2.912	-3.6845	**dlnmp**	-4.5819	-4.5273	-4.489	-4.4226
RE	-1.9076	-1.9003	-2.0779	-1.9333	**dre**	-4.9214	-4.2271	-5.0357	-4.5632
95% critical value	*-2.9798*		*-3.5943*		***95% critical value***	*-2.985*		*-3.6027*	

3.5.1.2 Structural breaks

Alston and Chalfant (1991) demonstrated how sensitive the results and inferences based on structural change in meat demand studies are, for the specification choice of the model. They pointed out that the structural change hypothesis has received widespread support in the past from agricultural economists who tried to model meat demand. Purcell (1989) went as far as criticizing the profession of agricultural economists and indicated that as late as 1987, journal articles still reflected disagreement regarding whether a shift in the U.S. meat demand had occurred. Alston and Chalfant (1991) concluded that there remains too little agreement regarding the structural change in demand analysis, and urge the profession to take the “con” out of demand analysis. They recommended analysts to pay more attention to the fragility of inferences that can be drawn from models that are built on a whim, and be much more cautious in basing recommendations upon fragile inferences (Alston and Chalfant, 1991).

Newbold, Rayner and Kellard (2000) developed a systematic method to identify and capture the effect of structural breaks. According to Alemu, Oosthuizen and Van Schalkwyk (2002), this method enables the analyst to detect and evaluate exogenous variables, which, amongst others, could result from transitions to new policy regimes.

In order to detect periods in which structural breaks occur, a set of residuals from the fitted LA/AIDS share equations (refer Chapter 5) were examined, and the structural breaks are then the period(s) where the residuals exceeded two standard deviations. These

Figures 3.11 to 3.14 show the residual plots of the four different meat budget share equations, in a 2 standard error band. As explained above, when the residual leaves the 2 standard error band in a specific year, an intercept and slope dummy variable are introduced into the equation for that specific year. Figure 3.11 indicates that in the case of the beef share equation, the residuals vary between the 2 standard error bands, thus there is no indication of structural breaks.

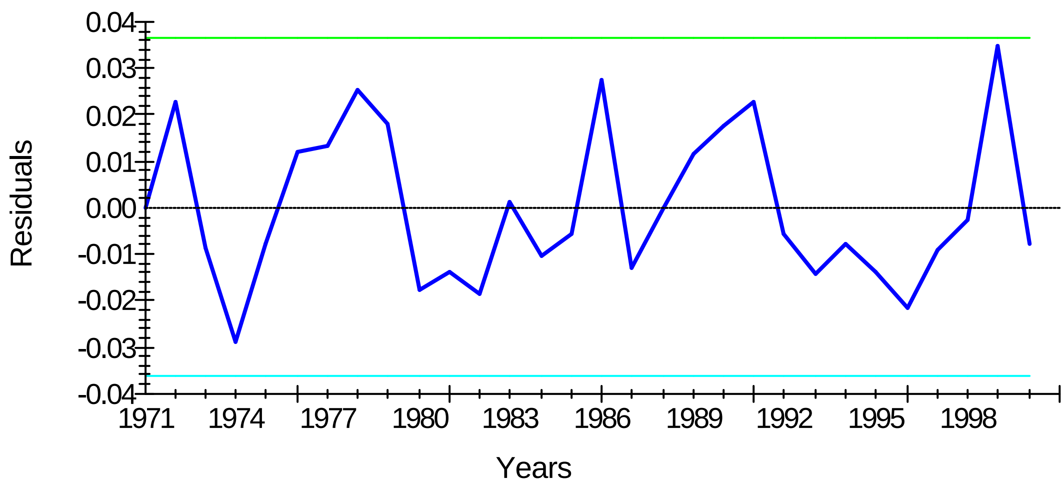

Figure 3.11: Residual plot of the beef share equation in 2 standard error bands

The residual plot for the chicken share equation is shown in Figure 3.12. The residual for the year 1999 passed the negative 2 standard error, and touched the positive 2 standard error band during 1996. This coincides with the imposition of an import tariff of R2.2 per kg in 1996 and a so-called “anti dumping tariff” in 1999 to prevent large amounts of chicken imports.

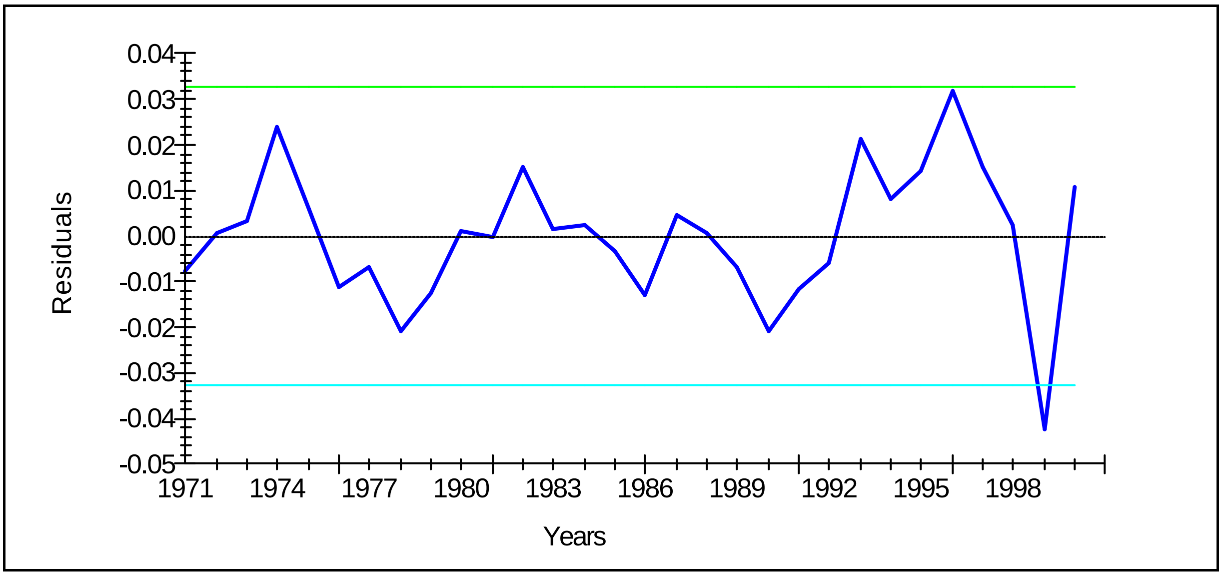

Figure 3.12: Residual plot of the chicken share equation in 2 standard error bands

From Figure 3.13 it is clear that a structural break occurred during 1991/1992 in the pork industry. The explanation of the break in practical terms is not that clear cut as in the case of chicken. A possible explanation for this is twofold. Firstly during the same time, the deregulation process of the agricultural sector started. Secondly, when looking at Figure 3.9, it is clear that the per capita consumption of pig meat increased dramatically, and major drop in producer prices were seen, which can be attributed mainly to a relative oversupply of pork.

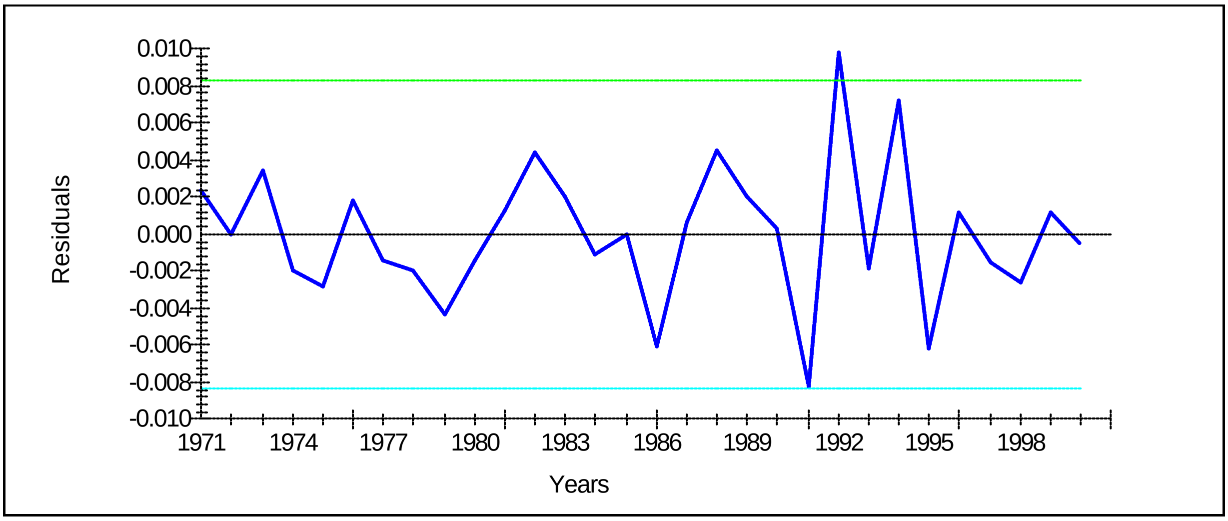

Figure 3.13: Residual plot of the pork share equation in 2 standard error bands

Lastly, Figure 3.14 shows the residual plot of the mutton share equation. Two possible structural breaks occur, namely 1972 and 1980. A possible explanation for this is that 1972/73 can be characterised as a relative dry year, whereas favourable rainfall led to a record agricultural year during the 1980/81 production season. According to the results, these two extremes influenced the production and price of mutton.

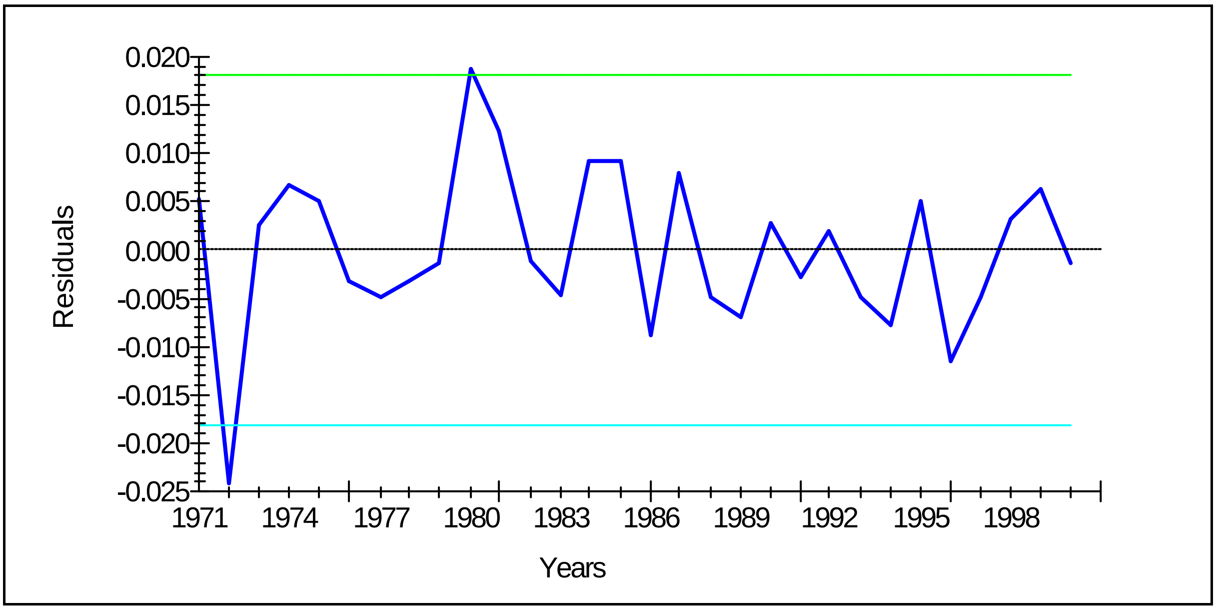

Figure 3.14: Residual plot of the mutton share equation in 2 standard error bands

3.5.2 Test for separability between meats and eggs

Meat products and eggs, which can *a priori* be expected to be substitutes in South Africa, are surely among the most important sources of protein in the diets of South African consumers. It is clear that, in order to estimate a demand system, commodities included in the system should belong to the same group from a two-stage budgeting procedure. If the meat products and eggs are not separable, the demand for red meat should be expressed as a function of the prices of all meats and eggs. On the other hand, if some of these products are separable, meat demand should only include the products which belong to the same group.

In this study, four meat products including beef, mutton, pork and chicken, together with eggs, were initially considered for testing separability among them. In order to test separability among the five commodities, a LA/AIDS is specified under an assumption that the four meat products and eggs are not separable for South African consumers:

$$w_{it} = a_i + \sum_{j=1}^{5} g_{ij} \ln p_{jt} + b_i (LnE - \sum_{i=1}^{n} w_{i,t-1} \ln p_{i.t}) + u_{i,t} \quad \text{i=1,2,…,5} \qquad 3.1$$

If meat products are assumed to be separable from eggs, the LA/AIDS for meat products can be specified as:

$$w_{it} = a_i + \sum_{j=1}^{4} g_{ij} \ln p_{jt} + b_i (LnE - \sum_{i=1}^{n} w_{i,t-1} \ln p_{i.t}) + u_{i,t} \quad \text{i=1,2,3,4} \qquad 3.2$$

Given this assumption, equation 3.1 is called the unrestricted model (UR) and 3.2 is called a restricted model (R). In order to test the validity of this assumption, the following null hypothesis should be tested for separability between meat products and eggs in South Africa:

$$H_0 : g_{i,eggs} = 0 \qquad 3.3$$

In order to test this hypothesis, equation 3.1 and 3.2 are estimated with annual time series data from 1970 to 2000, (NDA, 2002). In both equations, the share equation for eggs is dropped to impose the adding-up condition. The restrictions for symmetry and homogeneity are directly imposed in the estimation by means of a Restricted Seemingly Unrelated Regression (RSUR).

The F-test can be expressed in terms of the R^2 obtained from the restricted and unrestricted models:

$$\frac{(R^2_{UR} - R^2_R)/q}{(1 - R^2_{UR})/(n-k)} \approx F_{q,n-k} \qquad 3.4$$

where R^2_R and R^2_{UR} are R^2 values of the restricted and unrestricted models respectively.

If the calculated F value is greater than the critical value of the F-statistic with the degree of freedom in the numerator and the denominator, the null hypothesis in equation 3.3 is rejected.

The calculated value of the F-statistic is 2.385 (mutton share equation). The critical value at 5 per cent level of significance of the $F_{(1, 23)}$ distribution is 3.24. Therefore, at 95 per cent confidence, it can be accepted that the four meat products considered (beef, chicken, mutton and pork) are weakly separable from eggs. This implies that the demand model for meat should exclude eggs. Separability tests between other meat products, all reject the null hypothesis in equation 3.3, indicating that all four meat products should be included in the demand model.

Another separability test is the Likelihood Ratio (LR) test, which can be written as:

$$LR \equiv 2[L_{UR} - L_R] \sim c^{2}{}_{k-q} \quad \text{.......} \quad 3.5$$

where L_R and L_{UR} represent the maximum value of the log-likelihood function when the restrictions do and don't apply respectively.

If the calculated value of chi-square is larger than the critical value of chi-square with *(k-q)* degrees of freedom at the given critical level, the null hypothesis of weak separability can be rejected.

The log-likelihood test for weak separability between meat products and eggs, as in the case of the F-test, fails to reject the null-hypothesis of weak separability for all share equations. This indicates that the meat products are weakly separable from eggs, meaning that the demand for meat products in South Africa should exclude eggs.

These findings are supported by results which Van Zyl, Willemse and Weingartner (1992) obtained when they analyzed price interactions and market price leadership. The Haugh-Pierce chi-squared causality test was used to establish the existence and magnitude, if any, of the relation between eggs and various types of meat (beef, mutton, pork, chicken and fish). A strong measure of mutual dependence was found in the South African meat market. Their findings indicated firstly that price changes in the meat market do not affect the price of eggs. Neither do changes in the egg price exert any discernable effect on meat prices (Van Zyl *et al.*, 1992).

A further test indicates that there is a high mutual dependence between beef, mutton, pork and chicken prices. Van Zyl *et al.,* (1992) also indicates that mutton and pork prices are led by beef prices, and that beef may, to a certain extent, thus be regarded as the price leader in the meat market, also with respect to chicken.

From the two separability tests, F-test and log likelihood, the same conclusions regarding weak separability in the South African meat market can be drawn. In the estimation of the demand relation for red meat in South Africa, it is thus accepted that the four meat products, beef, chicken, pork and mutton, are not weakly separable from each other and will thus be included in the LA/AIDS model. Eggs, on the other hand, proved to be weakly separable from meat products, and for this reason was thus excluded from the demand model.

3.5.3 Test for exogeneity of the expenditure variable

One concern before the demand model can be estimated is whether the expenditure variable (X) in the model is exogenous. Edgerton (1993), showed that if the expenditure variable in the model is endogenous, i.e. correlated with the random error term, the SUR estimators are no longer unbiased.

LaFrance (1991) suggested the Hausman test to test the exogeneity of the expenditure variable. For the sake of completeness, the description of the Hausman test that follows was largely duplicated from Jung (2000).

Let q be a consistent and asymptotic efficient estimator. q^* is a consistent, but inefficient, estimator under that null hypothesis. The Hausman statistic can then be written as:

$$m = T(q^* - q)'[Var(q^*) - Var(q)]^{-1}(q^* - q), \quad \text{...} 3.6$$

which has a chi-square distribution with degrees of freedom equal to the number of unknown parameters in q. If m is larger than the critical value, then the null hypothesis of exogeneity is rejected.

To test for exogeneity, q is the SUR estimator, and q^* is the 3 stage least squares (3SLS) estimator. Thus, under the assumption of exogenous right-hand side (RHS) variables in the demand system, the SUR estimators are consistent and asymptotically efficient. If any of the RHS variables are endogenous, the SUR estimators are no longer consistent nor efficient, whereas the 3SLS estimators are inefficient but consistent.

Annual time series data from 1970 to 2000, obtained from the Abstracts of Agricultural Statistics (NDA, 2002) were used for estimation purposes. The calculated values of the chi-square for all meat products in the system are smaller than the critical chi-square values with 6 degrees of freedom at the 5 per cent significance level, indicating that the null hypothesis, namely that the expenditure variable is exogenous, can be accepted (see Table 3.3).

Therefore, the SUR estimators can be accepted as efficient, and can thus be used to estimate the LA/AIDS model for meat demand in South Africa. The instruments which were used to estimate the LA/AIDS model are the first lags of all budget share, price and expenditure variables and dummy variables to account for structural breaks where necessary.

Table 3.3: Exogeneity test of the expenditure variable

	Calculated test statistic	**DF**	**Critical Value (a =0.05)**
Beef	0.031069	6	12.59
Chicken	1.297827	6	12.59
Pork	0.014209	6	12.59
System	1.343105	18	28.87

3.6 Conclusion

This chapter provided an overview of the latest trends on production, consumption, expenditure and prices of beef, pork and mutton. Time series data were firstly tested to determine the univariate properties of the data and secondly to determine if any structural breaks occurred. Separability tests further showed that the proposed model should include beef, chicken, pork and mutton, whereas tests on the exogeneity of the expenditure variable indicated that the RSUR estimators are likely to be BLUE, and can thus be used with confidence.

CHAPTER **4**

AN EMPIRICAL APPLICATION OF THE ROTTERDAM DEMAND MODEL ON THE SOUTH AFRICAN RED MEAT INDUSTRY

"Facts do not speak for themselves. Statistical data convey a message only to the extent that they have been re-arranged and transformed in a way adapted to a theoretical hypothesis."

- L. Phlips (1974)

4.1 Introduction

As explained in the previous chapter, during the last two decades demand analysis has moved towards system-wide approaches. Currently numerous algebraic specifications of demand systems exist. Generally, different demand specifications have different implications (Lee *et al.,* 1994). As these authors indicated, two demand systems, the Rotterdam and the AIDS, have become popular in agricultural economics.

However, the assumptions used to parameterise these two systems have different implications. One example is that the marginal expenditure shares and Slutsky terms are assumed constant in the Rotterdam model, while they are assumed to be functions of the budget shares in the AIDS model (Lee *et al.,* 1994). Economic theory does not provide criteria to choose *ex ante* between these two systems, often forcing researchers to rely on statistical tests and inference. The choice between the two is thus an empirical, rather than a theoretical, question. This means that the AIDS and Rotterdam models cannot be tested directly against each other prior to estimation. Batren (1992) demonstrated further that the Rotterdam and the AIDS models are special cases of, and nested within, a more general demand system. He further suggested pair-wise and higher order tests for deciding which model best explains the data. Due to the fact that a choice between the two models cannot be made beforehand, both models are estimated for the purpose of this study. Elasticities were further calculated for both models, and compared.

The rest of the chapter is organised in two main sections: the first section covers the theoretical Rotterdam demand model, and in the second part, the Rotterdam model is used to estimate the demand relations for meat in South Africa. The parameter estimates are then used to calculate the own price, cross price and expenditure elasticities. These calculated elasticities as well as their statistical significance are then reported and explained.

4.2 The theoretical model

Deaton and Meulbauer (1999) indicated that the main difference between the LES and the Rotterdam models are that, instead of working with logarithmic level terms like the LES, the Rotterdam model works with first differentials. In first differenced terms, equation 2.14 yields:

$$d \log q_i = e_i d \log x + \sum_j e_{ij} d \log p_i \text{ ......} 4.1$$

The Slutsky symmetry equation is applied, as in the original LES as proposed by Stone (1954), to write $e_{ij} = e^*_{ij} - e_i w_j$, for compensated cross price-elasticity e_{ij}, so that 4.1 becomes:

$$d \log q_i = e_i \left(d \log x - \sum w_k d \log p_k \right) + \sum_j e^*_{ij} d \log p_j \text{ ......} 4.2$$

Equation 4.2 is the differential of the LES given in equation 2.15. However equation 4.2 doesn't lend itself to the imposition of symmetry, because the symmetry restriction also involves the budget share (w_i) variable. To overcome this problem, Johnson, Hassan and

Green (1984) showed that in practice, equation 4.2 can be multiplied by the average budget share between successive periods, $\overline{w}_i = (\frac{1}{2}(w_{i,t} + w_{i,t-1}))$, yielding:

$$\overline{w}_i d\log q_i = b_i d\log \overline{x} + \sum_j c_{ij} d\log p_j \quad \text{4.3}$$

where

$$d\log \overline{x} = d\log x - \sum \overline{w}_k d\log p_k = \sum \overline{w}_k d\log q_k \quad \text{4.4}$$

$$b_i = \overline{w}_i e_i = p_i \frac{\partial q_i}{\partial x} \text{ and} \quad \text{4.5}$$

$$c_{ij} = \overline{w}_i e^*_{ij} = \frac{p_i p_j s_{ij}}{x} \quad \text{4.6}$$

and where,

- the first equality in equation 4.4 is the definition of $d\log \overline{x}$, which should be regarded as an index representing the proportional change in the real expenditure;
- s_{ij} is the (i, j)th term of the Slutsky substitution matrix;
- $b_i = \overline{w}_i e_i$ is the marginal propensity to spend on the i^{th} good,

Deaton and Meulbauer (1999) indicate that, although all this may seem a rather circuitous way of repeating Stone's (1954) version of the LES, the somewhat unorthodox appearance of the Rotterdam system is more than compensated for by the simplicity with which its parameters can be related to the restrictions of the theory. Theoretical demand restrictions for the Rotterdam model are adding-up, homogeneity and symmetry, which can be defined as follows for all *i* and *j*:

Adding-up: $\sum_k b_k = 1; \sum_k c_{kj} = 0$ 4.7

Homogeneity: $\sum_k c_{jk} = 0$; 4.8

Symmetry: $c_{ij} = c_{ji}$ 4.9

The homogeneity and symmetry restrictions can be tested and imposed equation by equation, which is not the case with the adding-up restriction. The positive results generated by the Rotterdam model are that now, for the first time, a model has been developed that has a substitution matrix estimated subject only to symmetry, and that it is possible to identify substitutes and complements directly from the estimation.

4.3 Estimation results

According to the principle of two-stage budgeting, the test for separability conducted in Chapter 3 indicated that the red meat demand model should include only the four meat products, namely beef, chicken, mutton and pork. As explained earlier, the adding-up restriction is automatically satisfied when the variables (budget shares, price index and real expenditure term) of the Rotterdam model are calculated. The restrictions of homogeneity and symmetry, explained in Chapter 2, are firstly tested by means of the unrestricted SUR estimation procedure in Micro Fit 4.1. The calculated Wald statistics and corresponding p-values for testing these hypotheses, restrictions are shown in Table 4.1 below.

The homogeneity restriction implies that the sum of the nominal price parameters in each share equation adds up to 0. The null hypotheses are thus that the prices are homogeneous of degree zero, whereas the alternative hypothesis indicates non-homogeneous prices. The symmetry restriction on the other hand restricts cross-price derivatives of the demand functions to be identical.

The recorded p-values in Table 4.1 measure the probability of an error when rejecting the null hypothesis. The p-values for all the restrictions (homogeneity and symmetry), in all three-share equations, indicate that the probability of making an error when rejecting any of the null hypotheses are at least greater than 9%. It can thus be concluded that price parameters are homogeneous of degree zero and symmetric in the South African LA/AIDS meat demand model.

Table 4.1: Wald test statistics for testing homogeneity and symmetry restrictions for the Rotterdam model applied to the South African meat demand

Restriction	Wald test statistic	p-value
Homogeneity in:		
Beef share equation	2.765	0.096
Chicken share equation	0.625	0.429
Pork share equation	0.105	0.745
Symmetry for:		
Beef and Chicken price parameters	2.452	0.117
Beef and Pork price parameters	1.200	0.273
Chicken and Pork price parameters	0.005	0.946

The tests for structural breaks, conducted in Chapter 3, indicated that dummy variables are necessary in the chicken share equation for the years 1996 and 1999. Four dummy variables, one intercept and one trend dummy variable, were included in the model. Only the intercept dummy for the year 1999 was statistically significant, and therefore included in the final model.

Figure 4.1 shows the residual plot of the chicken equation with the intercept dummy variable for 1999 included. It is clear that the dummy variable, accounts for the structural break, with the new residuals not close to the 2 standard error band.

In the case of the pork equation, the possible need for a dummy variable for the year 1992 was indicated. As in the case of chicken, an intercept and a trend dummy variable were included in the pork equation. Again only the intercept dummy was statistically significant and therefore kept in the model for further estimation purposes. Figure 4.2 shows that the intercept dummy variable included for 1992 accounts for the structural break in the pork equation.

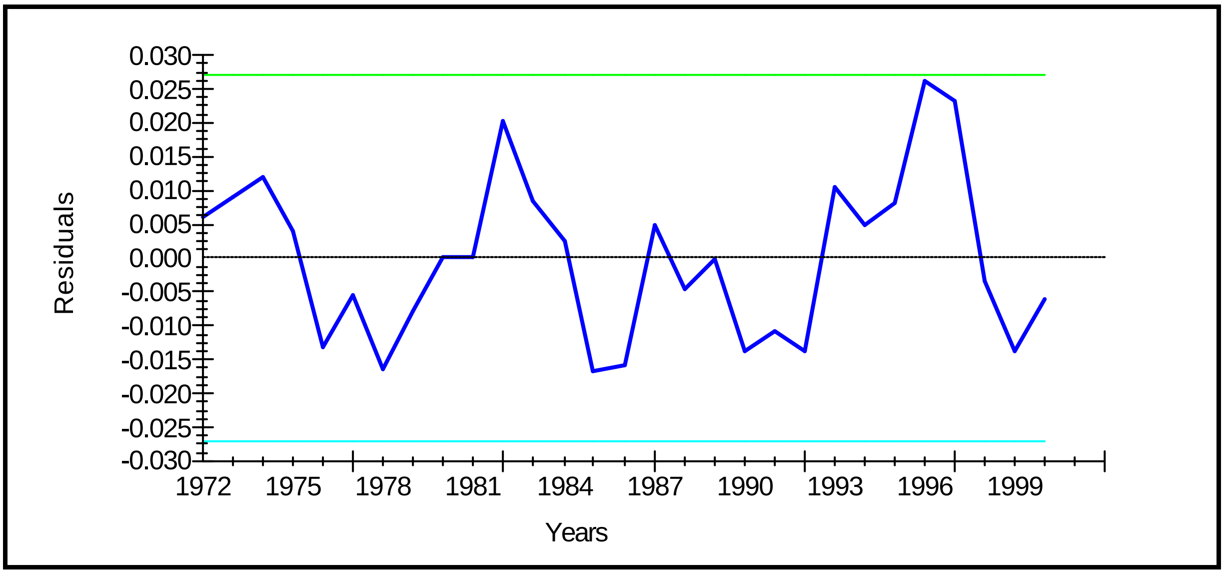

Figure 4.1: Residual plot of the chicken share equation in 2 standard error bands with an intercept dummy variable included for 1996, Rotterdam model

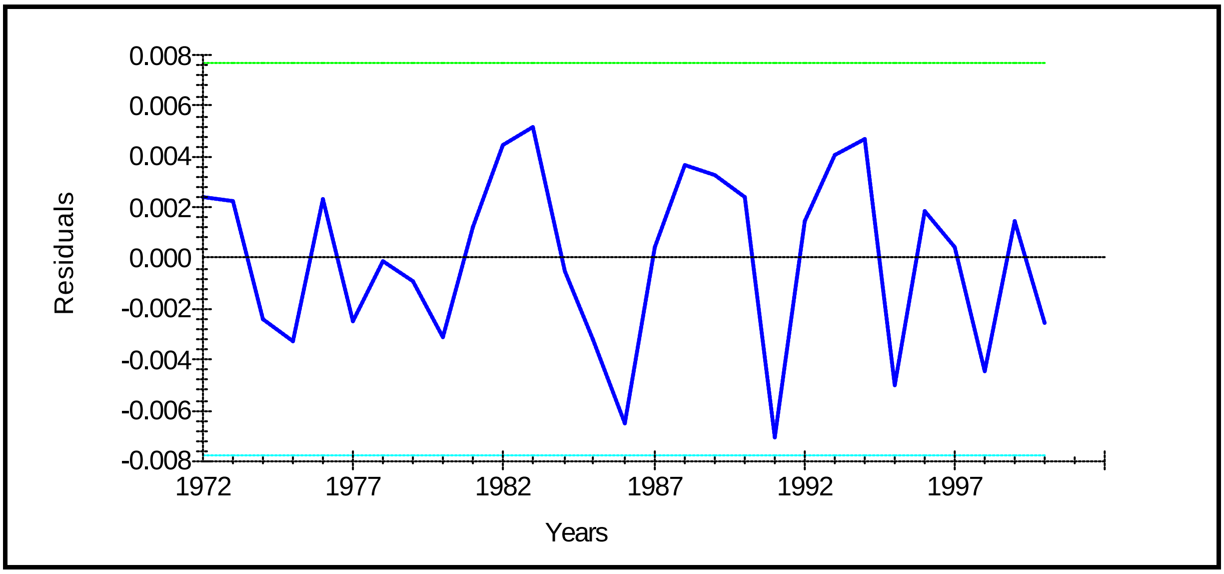

Figure 4.2: Residual plot of the pork share equation in 2 standard error bands with dummy variables included fo r 1992, Rotterdam model

Given that the three sets of restrictions namely adding-up, homogeneity and symmetry are satisfied, and the structural breaks accounted for, the restricted Rotterdam model can now be estimated. By using the Restricted Seemingly Unrelated Regression (RSUR) option in Micro Fit 4.1, and enforcing the homogeneity and symmetry restrictions into the estimation process, the parameter estimates and corresponding t-ratios for the Rotterdam demand model were obtained (see Table 4.2). The system weighted R^2 shows that 32.4 per cent of the variation in the data is explained by the independent variables in the Rotterdam model.

Table 4.2: Parameter estimates of the Rotterdam model

		Dependent variables			
		Beef	**Chicken**	**Pork**	**Mutton**
	Beef	-0.121			
		*(-2.34)***			
	Chicken	0.046	-0.034		
		(1.70)	*(-1.38)*		
	Pork	0.021	-.007	-0.018	
		*(2.76)***	*(-1.10)*	*(-3.09)****	
Explanatory	**Mutton**	0.055	-.0041	0.003	0.09
variables		*(1.28)*	*(-0.17)*	*(0.38)*	
	Expenditure	0.288	0.098	0.026	0.029
		*(3.72)****	*(2.35)***	*(2.24)***	
	Dummy			0.008	
	1992			*(3.58)****	
	Dummy		0.017		
	1996		*(2.32)***		
	System weighted R^2 = 0.3242				

t-ratios are in parentheses, where:
- * denotes significance at 10%
- ** denotes significance at 5%
- *** denotes significance at 1%

By dropping one equation, mutton in this case, to meet the adding-up restriction and applying the RSUR procedure in Micro Fit 4.1, the parameters for the Rotterdam model were obtained. The estimated results turned out to be quite satisfactory. Amongst the 12 estimated price parameters, 8 are statistically significant at the 5 per cent level of confidence, indicating that not all meat prices influence the consumption of other meat products. In the case of the real expenditure variable, it is significant at 10 per cent for the beef share equation and significant at 5 per cent for the chicken and pork share equations. It is further also shown that among the eleven significant parameters, seven are significant at the 1% confidence level, which is very good considering that annual economic time series data were used.

4.4 Price and expenditure elasticities

The compensated and uncompensated price elasticities of the Rotterdam model are represented by equation 4.10 and 4.11 respectively.

$$e_{ij} = \frac{g_{ij}}{w_i} \qquad 4.10$$

$$e_{ij} = \frac{g_{ij} - b_i w_j}{w_i} \qquad 4.11$$

The expenditure elasticity of the Rotterdam model is, in turn, represented by equation 4.12.

$$e_i = \frac{b_i}{w_i} \qquad 4.12$$

In order to evaluate the significance of the calculated elasticities, the variances of the compensated price, uncompensated price and expenditure elasticities can be calculated by applying the variance operator for the compensated and uncompensated price elasticities respectively as:

$$Var(e_{ij}*) = \frac{1}{\bar{w}_t^2} Var(\hat{g}_{ij}) \qquad 4.13$$

$$Var(e_{ij}) = \frac{1}{\bar{w}_t^2} Var(\hat{g}_{ij}) + \frac{\bar{w}_j^2}{\bar{w}_i^2} Var(b_t) - 2\left(\frac{\bar{w}_j^2}{\bar{w}_i^2}\right) Cov(\hat{g}, \hat{b}) \quad \ldots\ldots 4.14$$

$$Var(h_i) = \frac{1}{\bar{w}^2} Var(\hat{b}_i) \quad \ldots\ldots 4.15$$

All elasticities are calculated at the budget share sample mean. Table 4.3 shows the calculated compensated own and cross-price elasticities. The compensated own price elasticities are all negative as expected *a priori*, relatively inelastic and statistically significant. The compensated own price elasticity for mutton (-0.335) is the most elastic, followed by the own price elasticity for pork (-0.26), beef (-0.256) and chicken (-0.116).

Amongst the compensated cross-price elasticities, four unexpectedly carry negative signs, of which only two are statistically significant. The rest of the cross-price elasticities are positive, as expected for substitute products, and statistically significant. In terms of the cross-price elasticities, the consumption of mutton shows the strongest substitution response for the price of beef (0.34), whereas the consumption of beef isn't as responsive to the price of pork (0.05). The second strongest substitute response is the consumption of pork for the price of beef (0.315), followed by chicken for beef (0.153) and beef for mutton (0.116). All the other cross-price elasticities are less than 0.1.

Table 4.3: Compensated elasticities of South African meat products, Rotterdam model (1970 – 2000)

	Beef	**Chicken**	**Pork**	**Mutton**
Beef	**-0.256***	0.153*	0.315*	0.340*
	(-12.82)	*(9.31)*	*(15.16)*	
Chicken	0.096*	**-0.116***	-0.104*	-0.026
	(9.31)	*(-7.60)*	*(-6.03)*	
Pork	0.045*	-0.024*	**-0.260***	0.021*
	(15.17)	*(-6.03)*	*(-16.92)*	
Mutton	0.116*	-0.014	0.049*	**-0.335**
	(7.06)	*(-0.94)*	*(2.09)*	

* Indicates significance at the 5 per cent level, t-ratios are in parentheses.

As explained in Chapter 2, uncompensated elasticities can be seen as the compensated elasticity, together with the added effect of changes in relative income, on the consumption of the particular product. To date the majority of demand studies in South Africa has estimated the "normal" or uncompensated price elasticities.

Table 4.3 shows the calculated uncompensated price elasticities for meat products at their sample means of the budget shares in each commodity share equation. As in the case of the compensated own price elasticities, the uncompensated own price elasticities also carry the *a priori* expected negative signs and are also statistical significant at the 5 percent level. The uncompensated own price elasticities of beef (-0.544), chicken (-0.131), pork (-0.261) and mutton (-0.923) are significantly higher (more elastic) than the compensated estimates.

As in the case of the compensated cross-price elasticities, not all the uncompensated cross-price elasticities behaved as expected from economic theory. Only 5 out of the 12 uncompensated cross-price elasticities are positive, of which three are statistically significant. Out of the seven uncompensated cross-price elasticities carrying a negative sign, only four are statistically significant.

Table 4.4: Uncompensated elasticities of South African meat products, Rotterdam Model (1970 – 2000)

	Beef	Chicken	Pork	Mutton
Beef	**-0.544***	0.128*	0.308*	-1.386
	(-22.26)	*(6.278)*	*(11.98)*	
Chicken	-0.084*	**-0.131***	-0.109*	-1.109
	(-6.22)	*(-7.72)*	*(-5.52)*	
Pork	0.004	-0.027*	**-0.261***	-0.225*
	(1.09)	*(6.34)*	*(-16.83)*	
Mutton	0.018	-0.022	0.047*	**-0.923**
	(1.04)	*(1.46)*	*(1.94)*	

* Indicates significance at the 5 per cent level, t-ratios are in parentheses.

The calculated expenditure elasticities reported in Table 4.5 are all positive and relatively inelastic, except for mutton. The expenditure elasticities for beef and chicken are the only two that turned out to be statistically significant. The expenditure elasticities indicate that, of the four meat products, mutton is the only luxury product (expenditure elasticity > 1), with all others classified as necessities (expenditure elasticity < 1).

Table 4.5: Expenditure elasticities of South African meat products, Rotterdam model (1970 – 2000)

	Beef	**Chicken**	**Pork**	**Mutton**
Expenditure	0.607*	0.053*	0.015	3.642
	(20.35)	*(2.051)*	*(0.48)*	

* Indicates significance at the 5 per cent level, t-ratios are in parentheses.

4.5 Summary

This chapter started by covering the theoretical framework of the Rotterdam model. Secondly the empirical estimation procedure of the Rotterdam model on South African meat data was explained and the results that were obtained, reported. Lastly the estimated own price, cross price and expenditure elasticities were reported. Amongst the 16 estimated compensated price elasticities, 13 (81%) are statistically significant at the 95 per cent confidence level. In the case of the uncompensated price and expenditure elasticities, 63% and 50% are statistically significant at the 95 per cent level of confidence respectively.

Except for certain cases of chicken and pork, the calculated elasticities performed well according to *a priori* expectations. Where comparable, the magnitudes of the calculated elasticities are less elastic than previous South African, and some international estimates. A more in-depth comparison of the calculated elasticities is performed, together with the elasticities of the LA/AIDS, in the next chapter.

CHAPTER **5**

AN EMPIRICAL APPLICATION OF THE ALMOST IDEAL DEMAND SYSTEM (AIDS) ON THE SOUTH AFRICAN RED MEAT INDUSTRY

"Consumption is the sole end and purpose of all production"
- Adam Smith

5.1 Introduction

This chapter describes the estimation procedure and results of the AIDS model for the South African red meat industry. The uncompensated and compensated price and expenditure elasticities of four meat products, including beef, chicken, mutton and pork, are also calculated and explained.

This chapter describes the specification of a Linear Approximated Almost Ideal Demand System (LA/AIDS), which was developed for the South African red meat industry. Annual time series data were used for estimation purposes. Specific quantities consumed and prices of red meats were obtained from the Abstracts of Agricultural Statistics (NDA, 2002).

5.2 The theoretical specification of the AIDS model

The i^{th} equation in the AIDS model can be defined as:

$$w_{it} = a_i + \sum_{j}^{n} g_{ij} \ln p_{jt} + b_i \ln(X_t / P_t) + u_{it} \qquad \text{i= 1,…,n} \ldots\ldots 5.1$$

and where, in observation t;

- w_{it} is the budget (expenditure) share of the i^{th} good;
- p_{jt} is the nominal price of the j^{th} *good*;
- $\ln X_t$ is total expenditure;
- u_{it} is the random or error term; and
- $\ln P_t$ is the translog price index defined by:

$$\ln P_t = a_0 + \sum a_j \ln p_j + \frac{1}{2}\sum_{i}^{n} \sum_{j}^{n} g_{it} \ln p_{it} \ln p_{jt} \qquad \text{t = 1,…,T} \ldots\ldots 5.2$$

This price index makes the system non-linear, which normally complicates the estimation process. In order to overcome this problem of non-linearity, Deaton and Meulbauer (1980) suggest using another linear price index. The process of linearizing the AIDS is discussed in the following section.

5.2.1 Linearizing the AIDS

As explained above, the only difference between the AIDS and its linear version, the LA/AIDS, lies in the specification of the price index. Several authors including Green and Alston (1990); Pashardes (1993); Alston *et al.*, (1994); Buse (1994); Hahn (1994); Moschini, Moro and Green (1994); Moschini (1995); Asche and Wessels (1997) have discussed the relationship between the linear and nonlinear specifications. In several of these studies, Monte Carlo studies were used to show that the use of differential functional forms of the index in the LA/AIDS provides results that compare more or less well to the AIDS model, (Asche and Wessels, 1997).

The Stone's price index, as suggested by Deaton and Meulbauer (1980), which can be used to replace the translog price index, is defined as follows:

$$LogP = \sum_{i=1}^{n} w_{i,t} \log p_{i,t} \text{ ....} 5.3$$

Eales and Unnevehr (1988) showed that the substitution of the Stone's price index for the translog price index causes a simultaneity problem, because the dependent variable (w_{it}), also appears on the right hand side of the LA/AIDS. They suggested using the lagged share ($w_{i,\ t-1}$) for equation 5.3. Replacement of equation 5.3 with the lagged shares, into equation 5.1 yields the LA/AIDS, given by:

$$w_{it} = a_i + \sum_{j}^{n} g_{ij} \ln p_{jt} + b_i (LnX - \sum_{i=1}^{n} w_{i,t-1} \ln p_{i.t}) + u_{i,t} \text{ ....} 5.4$$

Theoretical demand restrictions, which can be tested and imposed on the LA/AIDS, includes adding-up, homogeneity and symmetry. These restrictions can be written mathematically as follows:

Adding-up: $\sum_i a_i = 1, \sum_i g_{ij} = 0, \sum_i b_i = 0$ 5.5

Homogeneity: $\sum_j g_{ij} = 0$ 5.6

Symmetry: $g_{ij} = g_{ji}$ 5.7

In addition to the Stone's price index, three other price indices, which can also be used to replace the translog price index, have been suggested by Asche and Wessels (1997). Among them are:

Tornqvist index: $LnP_t = \frac{1}{2} \sum_{i=1}^{n} (w_{i,t} + w_i^0) \ln(\frac{p_{i,t}}{p_i^0})$ 5.8

Paasche index: $LnP_t = \sum_{i=1}^{n} w_{i,t} \ln(\frac{p_{i,t}}{p_i^0})$ 5.9

Laspeyre index: $\ln P_t = \sum_{i=1}^{n} w_{it}^0 \ln(p_{it} / p_i^0)$, ...5.10

where the superscript 0 represents the base period, and all other parameters are defined as above.

5.3 Estimated results

As discussed in the previous two chapters, the separability test indicated that the meat demand model should include four meat products, namely beef, chicken, mutton and pork. It was also proved that the general demand restrictions are enforced in the estimation of the LA/AIDS. Enforcing homogeneity and symmetry directly in the estimation of the Seemingly Unrelated Regression (SUR), restricted the demand system. In order to meet the adding-up condition, one share equation was dropped.

As in the case of the Rotterdam model, the adding-up restriction is automatically satisfied when the variables (budget shares, price index and real expenditure term) of the AIDS model is calculated. The restrictions of homogeneity and symmetry are firstly tested by means of the unrestricted SUR estimation procedure in Micro Fit 4.1. The calculated Wald statistics and corresponding p-values for testing these hypotheses' restrictions are shown in Table 5.1 below.

The homogeneity restriction implies that the sum of the nominal price parameters in each share equation adds up to 0. The null hypotheses is thus that the prices are homogeneous of degree zero, whereas the alternative hypothesis indicates non-homogeneous prices. The symmetry restriction in turn, restricts cross price derivatives of the demand functions to be identical.

For homogeneity and symmetry, in all three-share equations indicates that the probability of making an error when rejecting any of the null hypotheses is greater than at least 14%. As with the Rotterdam model, it can be concluded that price parameters are homogeneous of degree zero and symmetric in the South African LA/AIDS meat demand model.

Table 5.1: Wald test statistics for testing homogeneity and symmetry restrictions for the South African LA/AIDS meat demand model

Restriction	Wald test statistic	P-Value
Homogeneity in:		
Beef share equation	0.401	0.526
Chicken share equation	1.925	0.165
Pork share equation	0.294	0.588
Symmetry for:		
Beef and Chicken price parameters	0.013	0.909
Beef and Pork price parameters	2.115	0.146
Chicken and Pork price parameters	0.014	0.907

The structural breaks were also tested in the LA/AIDS model. Different from the Rotterdam model, the intercept dummies for 1996 and 1999 were both statistically significant at the 5 per cent level and thus included in the final model. Figure 5.1 show the residual plot for the chicken share equation after the two intercept dummies variables have been included. It is clear that the structural breaks are accounted for.

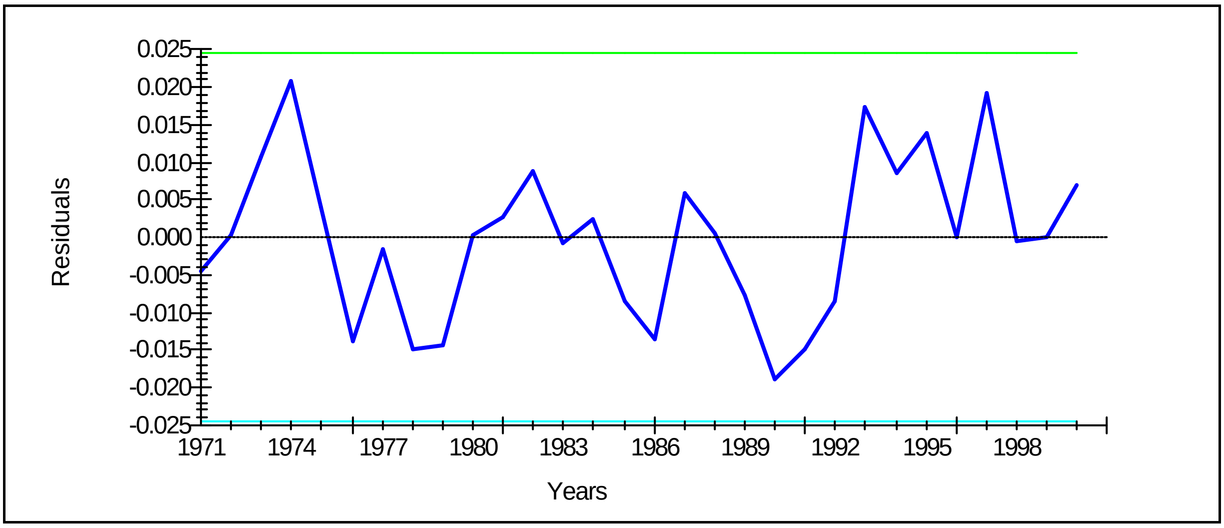

Figure 5.1: Residual plot of the chicken share equation in 2 standard error bands with dummy variables included for 1996 and 1999

Figure 5.1 show the residual plot for the pork share equation in the LA/AIDS model after the dummy variable has been included. Similar to the Rotterdam model, only the intercept dummy variable included were statistically significant at the 5 per cent level. During 1991 and 1994, the residual came close to the 2 standard error bands, but didn't exceed it. Dummy variables were initially included in the regression, but weren't statistically significant at the 5% level of confidence, and therefore not included for final estimation purposes.

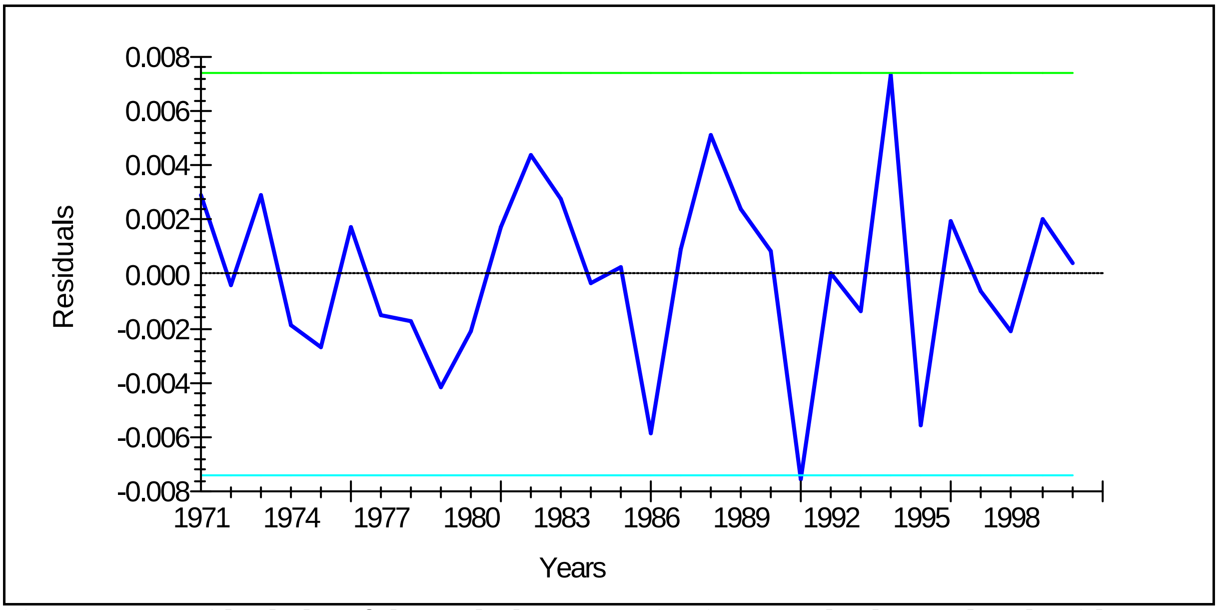

Figure 5.2: Residual plot of the pork share equation in 2 standard error bands with dummy variables included for 1992

The three sets of demand restrictions were satisfied as well as the structural break accounted for, consequently, the restricted LA/AIDS model can be estimated. Table 5.2 reports the RSUR parameter estimates and corresponding t-ratios for the LA/AIDS demand model.

As in the case of the Rotterdam model, the mutton share equations were dropped for estimation purposes to meet the adding-up requirement. The estimated results turned out to be quite satisfactory. Among the 12 estimated price parameters, 8 are statistically significant at the 5 per cent level of confidence, indicating that not all meat prices influence the consumption of other meat products.

The real expenditure variable is significant at 10 per cent for the beef share equation and significant at 5 per cent for the chicken share equation, but insignificant for the pork share equation. It is further also shown that, amongst the eleven significant parameters, seven are significant at the 1% confidence level, which is very good concerning that annual economic time series data were used. The system weighted R^2, indicates that the independent variables in the LA/AIDS model, explain 42.1 per cent of the variation in the data, which is significantly higher than the Rotterdam model.

Table 5.2: Parameter estimates of the LA/AIDS model

		Dependent variables			
		Beef	**Chicken**	**Pork**	**Mutton**
Explanatory variables	**Beef**	0.172			
		*(4.13)****			
	Chicken	-0.1	0.151		
		*(-3.85)****	*(5.95)****		
	Pork	-.007	-.0316	0.422	
		(-0.84)	*(-5.06)****	*(7.35)****	
	Mutton	-.067	-.020	-0.004	0.091
		*(-2.49)***	*(-0.92)*	*(-0.48)*	
	Expenditure	0.115	-0.141	-0.004	0.029
		*(1.38)**	*(-2.4)***	*(-0.22)*	
	Dummy 1992			0.011	
				*(3.19)****	
	Dummy 1996		0.020		
			*(2.1)****		
	Dummy 1999		-.027		
			*(2.099)***		
	System weighted R^2 = 0.4215				

t-ratios are in parentheses, where:
* denotes significance at 10%
** denotes significance at 5%
*** denotes significance at 1%

5.4 Price and expenditure elasticities

Compensated and uncompensated elasticities, as explained in Chapter 2, were calculated. The formulas as reported by Jung (2000) were used to calculate the compensated and uncompensated price elasticities, shown in equation 5.11 and 5.12 respectively:

$$e_{i,t}^{*} = e_{it} + \bar{w} + \hat{b}\left(\frac{\bar{w}_j}{\bar{w}_i}\right) = -d + \frac{\hat{g}_{it}}{\bar{w}_t} + \bar{w}_j \quad \text{I,j=1,2,…,n.} \qquad 5.11$$

$$e_{i,t} = -d + \frac{\hat{g}_{it}}{\bar{w}_t} - \hat{b}_t\left(\frac{\bar{w}_j}{\bar{w}_i}\right) \qquad 5.12$$

where δ=1 for *i=j* and δ=0 otherwise. The average expenditure shares are represented by $\bar{w}_t$ whereas, $\hat{b}_t$ and $\hat{g}_{it}$ are RSUR parameter estimates for the LA/AIDS model.

The variances of the compensated and uncompensated price elasticities can be calculated by applying the variance operator for the compensated and uncompensated price elasticities respectively as:

$$Var(e_{ij}*) = \frac{1}{\bar{w}_t^2} Var(\hat{g}_{ij}) \qquad 5.13$$

$$Var(e_{ij}) = \frac{1}{\bar{w}_t^2} Var(\hat{g}_{ij}) + \frac{\bar{w}_j^2}{\bar{w}_i^2} Var(b_t) - 2\left(\frac{\hat{\bar{w}}_j^2}{\bar{w}_i^2}\right) Cov(\hat{g}, \hat{b}) \qquad 5.14$$

The formula, taken from Jung (2000) for the expenditure elasticity can be written as:

$$h_i = 1 + \frac{\hat{b}_i}{\bar{w}_i} \qquad 5.15$$

The variance of the expenditure elasticity can be calculated by:

$$Var(h_i) = \frac{1}{\bar{w}^2} Var(\hat{b}_i) \quad \text{.......} 5.16$$

Compensated, uncompensated and expenditure elasticities, together with the corresponding variances, were calculated from the estimated parameters given in Table 5.2 by using equations 5.11 to 5.16.

Table 5.3 shows the calculated compensated price elasticities at the sample mean of the budget share in each commodity share equation. Compensated own price elasticities of all four meat products are relatively inelastic, carry negative signs as expected *a priori*, and are statistically significant at the 5 per cent level. The compensated own price elasticity for pork (-0.31) is the most elastic, followed by the own price elasticity for mutton (-0.28), chicken (-0.19) and beef (-0.16).

Except for the cross-price elasticity between chicken demand and pork price, and vice versa, all other cross-price elasticities carry positive signs as expected for substitute products. Similar to the own price elasticities, the cross-price elasticities are all statistically significant at the 5 per cent level. Regarding the cross-price elasticities, the consumption of pork shows the strongest substitution response for the price of beef (0.38), whereas the consumption of beef isn't as responsive to the price of pork (0.05). The second strongest substitute response is the consumption of mutton for the price of chicken (0.17), followed by chicken for beef (0.14) and pork for mutton (0.1). All the other cross-price elasticities are less that 0.1.

Compared to the compensated US aggregate meat elasticities in Table 2.1, (Eales and Unnevehr, 1988), and the compensated price elasticities from the Rotterdam model in Table 4.3, the figures in Table 5.4 are more or less of the same magnitude. Although the budget shares for the South African and US circumstances differs, both the LA/AIDS and Eales and Unnevehr (1988), found pork to be the most elastic regarding changes in its own price.

Table 5.3: Compensated elasticities of South African meat products, LA/AIDS model (1970 – 2000)

	Beef	Chicken	Pork	Mutton
Beef	**-0.161***	0.139*	0.375*	0.060*
	(-9.99)	*(8.75)*	*(17.63)*	
Chicken	0.087*	**-0.193***	-0.172*	0.173*
	(8.75)	*(-12.43)*	*(-10.17)*	
Pork	0.053*	-0.039*	**-0.305***	0.043*
	(17.63)	*(-10.17)*	*(-19.65)*	
Mutton	0.020*	0.094*	0.103*	**-0.277**
	(2.00)	*(7.01)*	*(4.75)*	

* Indicates significance at the 5 per cent level, t-ratios are in parentheses.

Table 5.4 shows the calculated uncompensated price elasticities for meat products at their sample means of the budget shares in each commodity share equation. As for the case of the compensated own price elasticities, the uncompensated own price elasticities also carry the *a priori* expected negative signs and are statistical significant at the 5 per cent level. The uncompensated own price elasticities of beef (-0.75), chicken (-0.35), pork (-0.37) and mutton (-0.47) are significantly lower compared to some of the previous estimates for meat in South Africa. Hancock *et al.* (1984) also estimated price elasticities but for the time period 1962 to 1981, which were significantly higher for some products, compared to the figures just mentioned. The own price elasticities they reported, were beef (-0.96), poultry (-1.66), pork (-1.86) and mutton (-1.93).

The uncompensated cross-price elasticities, although statistically significant at the 5 per cent level in most cases, do not all show the expected positive signs. A possible explanation for these unexpected signs is that when consumers experience a change, whether positive or negative, in their relative disposable income (DI), most households will probably first decide on the percentage of this change to be spent/cut on savings and expenditure. Consumers will probably first decide on the amount to be saved, for example, they can decide to save x per cent more in the case of an increase in DI or to save z percent less in the case of a decrease in DI. The remainder of the change in DI after the decision has been made regarding savings, leaves consumers with a certain amount to be spent on goods and services. Meat products are part of the conglomeration of goods and services.

With meat being considered a normal product or, in some cases, a luxury product for a large part of the South African population, a rise in disposable income will lead to an increase in the consumption of meat, i.e. a positive income elasticity.

Considering the income effect as being the difference between the compensated and uncompensated cross-price elasticities, a further possible explanation for the unexpected signs, is that South African consumers could tend to have a preference for a specific meat/meats. In the case of the uncompensated cross-price elasticities, where the income effect is also captured in the elasticity, it seems that some of the meat products tend to be classified as complements (negative cross-price elasticity). This implies that, as the DI of consumers increase consumers may tend to consume different meat products together with some other complements as well, instead of only one meat product together with other complements.

Table 5.4: Uncompensated elasticities of South African meat products, LA/AIDS Model (1970 – 2000)

	Beef	Chicken	Pork	Mutton
Beef	**-0.750***	-0.11*	-0.074*	-0.5*
	(-33.87)	*(-4.72)*	*(-2.49)*	
Chicken	-0.282*	**-0.35***	-0.454*	-0.178
	(-20.46)	*(-18.5)*	*(-21.24)*	
Pork	-0.030*	-0.074*	**-0.37***	-0.036*
	(-8.18)	*(-16.39)*	*(-23.33)*	
Mutton	-0.18*	0.009	-0.05*	**-0.468**
	(-15.58)	*(0.63)*	*(-2.17)*	

* Indicates significance at the 5 per cent level, t-ratios are in parentheses.

When calculating uncompensated elasticities, Jung (2000) found some of the calculated uncompensated cross price elastisities to be negative. Products for which Jung (2000) found unexpected signs include the cross-price elasticity of imported beef for chicken, imported beef for crustacean (a fish group), pork for Hanwoo beef, pork for imported beef, pork for chicken, pork for crustacean, chicken for imported beef, chicken for pork, chicken for crustacean, fish for pork, fish for chicken, crustacean for imported beef, crustacean for pork, crustacean for chicken, mollusk for beef and mollusk for chicken. Most of the elasticities mentioned were found to be statistically insignificant, therefore no further explanations were made with regard to the negative signs.

Compared to with the compensated elasticities, the uncompensated own price elastisities of beef are the most elastic, followed by mutton, pork and lastly chicken. Chicken is the most price inelastic, implying that the consumption of chicken is the least sensitive to changes in its own price, which confirms studies conducted in other countries like the U.S., U.K. and Korea (Jung, 2000). The fact that beef is the most elastic is also supported by the study that was done by Van Zyl *et al. (1998).*

The calculated expenditure elasticities for South African meat products, which are all positive and statistically significant at the 5 per cent level, indicate that all meat can be considered as normal to luxury goods, as expected *a priori* (see Table 5.5).

Expenditure elasticities for beef (1.24) and mutton (1.18) are greater than one, indicating that they can be considered luxury goods. Although the expenditure elasticity for pork (0.947) is less that one, it is close enough to one, which is the cut-off point between luxury and necessary products. The relative low expenditure elasticity of chicken (0.53) indicates that chicken can be considered a necessity as a protein source in South African diets. This also reflects the distribution of the South African population.

Table 5.5: Expenditure elasticities of South African meat products, LA/AIDS model (1970 – 2000)

	Beef	Chicken	Pork	Mutton
Expenditure	1.243*	0.526*	0.948*	1.182
	(38.60)	*(14.56)*	*(21.6)*	

* Indicates significance at the 5 per cent level, t-ratios are in parentheses.

5.5 Summary

This chapter covered the Almost Ideal Demand System (AIDS), as well as a description of the Linearization thereof, called the Linearized Approximated Almost Ideal Demand System (LA/AIDS).

In the next chapter, attention is paid to some *a priori* considerations, and a test is conducted to choose the superior model, Rotterdam versus LA/AIDS. The study is then concluded by a summary and recommendations.

CHAPTER 6

CONCLUSION AND RECOMMENDATIONS

"A fragile inference is not worth taking seriously"

- E. Leamer (1985)

6.1 Introduction

This study focussed mainly on the estimation of demand relations for meat in South Africa. Certain difficulties that can arise from estimating empirical demand systems, like model choice, separability and exogeneity of the data, theoretical demand properties and econometric time series techniques, were identified and treated accordingly.

The demand relations for meat in South Africa were estimated by means of two different demand models, namely the Rotterdam and AIDS. In the next section, a non-nested test is used to select the superior model. The last section of this chapter provides some recommendations on how to use and interpret the results, and possible suggestions for further research is also provided.

6.2 Choice between LA/AIDS and Rotterdam models

The Rotterdam and LA/AIDS models were applied on South African meat data in Chapters 4 and 5 respectively. The objective of this section is the rejection of one model in favour of the other. Alston and Chalfant (1993) specified a nested test to choose between the

LA/AIDS and Rotterdam models, based on the assumption that the explanatory or right hand side (RHS) variables are **approximately** equal. Instead of making these adjustments in order to assume that the RHS variables of the two models are equal, a non-nested test can be used. In general, two distinct models may have some explanatory variables in common, as in the case of the Rotterdam and LA/AIDS.

6.2.1 Non-nested test

The theoretical specification of the non-nested test that follows was largely obtained from three sources, including Pesaran and Pesaran (1997), Greene (2000) and Johnston Dinardo (1997). If one considers the following two models M1 and M2 model:

$$M_1:\ y = Xb + u_1 \qquad u_1 \approx N(0, s_1^2 I) \quad \text{.......... 6.1}$$

$$M_2:\ y = Zg + u_2 \qquad u_2 \approx N(0, s_2^2 I) \quad \text{.......... 6.2}$$

where X is a n ´ k vector and Z is a n ´ l vector.

As already mentioned, generally the two distinct models may have some explanatory variables in common, such that:

$$X = [X_1 X_*] \qquad Z = [X_1 Z_*] \quad \text{.......... 6.3}$$

Testing is accomplished by setting up a composite or artificial model within which both models are nested. This composite model can be written as:

$$M_3:\ y = (1-a)Xb + \partial a(Zg) + u \quad \text{.......... 6.4}$$

Where a is a scalar parameter.

When $a = 0$, M_3 reduces to M_1, and conversely, when $a = 1$, the composite model reduces to M_2. Davidson and MacKinnon (1981) suggested that, in order to test for M_1, the unknown ? vector in equation 6.4 can be replaced by its OLS regression estimate from M_2. The following hypotheses can now be tested:

H_0: a = 0

H_a: a ≠ 0

If H_0 is accepted, then M_1 is the superior model, and conversely, the rejection of H_0 implies the rejection of M_1 and choosing M_2.

6.2.2 Empirical test between Rotterdam and LA/AIDS models for South African meat demand

The non-nested test described in the previous paragraph can be made less complicated when applied to the Micro Fit 4.1 econometric software package. The practical test can be described as follows:

Firstly, M_1 and M_2 in equations 6.1 and 6.1 must be specified. Assume that, in this case, the LA/AIDS model is specified as M_1 and the Rotterdam model as M_2. The share equations are then individually regressed on the explanatory variables in a normal OLS regression. The non-nested test option is selected from the Hypotheses menu, after which the program requires a more indepth specification of the dependent variable of models M_1 and M_2. The dependent variable of M_1 (which is the first difference of the budget shares in each share equation) is specified as a difference form. In the final step, the dependent variable of M_2 must be specified in terms of the dependent variable for M_1. The non-nested test simulation results are then obtained. The test statistics that are then computed and reported by the Micro Fit 4.1 program, include:

- The P_E test statistic
- The Bera-McAlees test statistic (BM)

- The double-length regression test statistic (DL) , and
- The Cox's non-nested statistic computed by simulation.

In order to reach a conclusion, the Saragan's and the Vuong's likelihood criterion for M_1 vs M_2 is used.

Table A1 to A4 in Appendix A list the non-nested test results by simulation for all four-share equations (beef, chicken, pork and mutton). For all share equations, the Saragan's and Vuong's likelihood criterion selects the LA/AIDS model.

Interestingly enough, more or less the same conclusion can be reached when comparing the estimated elasticities, and its statistical significance, of the two models. Firstly, the compensated price elasticities are reported in Tables 4.3 and 5.3 for the Rotterdam and LA/AIDS models respectively. In the case of the Rotterdam model, 4 of the 16 estimated elasticities have unexpected signs and 1 is not statistically significant at the 5% level of confidence. Except for the two cross-price elasticities of pork for chicken and vice versa, the rest of the LA/AIDS compensated price elasticities all have the expected signs and are statistically significant at the 5% level of confidence.

In the case of the uncompensated elasticities on the other hand, 7 out of the 16 estimated Rotterdam elasticities have unexpected signs and 5 were not statistically significant. For the LA/AIDS model, 11 have the wrong sings and 2 were not statistically significant at the 5% level of confidence.

Lastly, the expenditure elasticities of both models carry the expected positive signs and all are statistically significant at the 5% level of confidence, except for the expenditure elasticity of pork in the Rotterdam model.

6.3 Recommendations for further research

Further research on the following aspect may be valuable to the red meat industry:

a. **The effect of non-price/income factors:** According to Bansback (1995), there has recently been a shift in emphasis in demand studies. He explains that, as an industry matures, companies have more opportunities to influence demand for their own product, depending on the degree to which they are able to add value, innovate and execute an effective marketing strategy.

   Bansback (1995) further shows that most approaches to the analysis of meat demand have concentrated mainly on the key price and income factors, assuming no significant change in taste factors. The reasons for this are threefold, namely limitations of some conventional demand analyses, the fact that price and income factors can explain most of these changes, and the difficulty of measuring other factors, except as a residuals.

   It is thus clear that there is a gap in the framework for analyzing the demand for meat. Future models need to be developed in such a way that they can better encompass the increasing amount of information on non-price/income such as versatility, enjoyment from eating, convenience, ethical, health and environmental concerns. This means that an aggregated approach, which combines the knowledge and inputs from different disciplines, should be more powerful than the current lack of dialogue between the disciplines (Bansback, 1995).

b. **Demand relations over the short run:** Annual time series data were used for estimation purposes of this study. By using short term data, i.e. quarterly or monthly, the short term elasticities can be estimated, which may further benefit decision making processes in the industry.

c. **The demand for different cuts and grades of meat in South Africa:** If the data used can be further broken down into the prices and quantities of different cut and grades, the demand relations for these categories can then be estimated.

d. **The demand for imported meat in South Africa:** Since a significant amount of meat is imported each year, and this mostly being lower quality cuts, the demand for meat from different counties will also benefit the industry. One possibility is to estimate a Source Differentiated Almost Ideal Demand System (SD/AIDS), which will provide insight on the demand for meat from different importing countries.

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