THE DEMAND FOR MEAT IN SOUTH AFRICA: AN ALMOST IDEAL ESTIMATION

PR Taljaard, ZG Alemu & HD van Schalkwyk[1]

Abstract

A Linear Approximated Almost Ideal Demand System (LA/AIDS), estimated in first differences, was used to anticipate the demand relations for meat (beef, chicken, pork and mutton) in South Africa from 1970 – 2000. Two tests for weak separability, including an F and Likelihood ratio version, failed to reject the null hypothesis of weak separability, confirming that the four meat products are separable, and should be modelled together. According to the Hausman exogeneity test, the expenditure term in the South African meat demand model is exogenous. As a result, a Restricted Seemingly Unrelated Regression (RSUR) was used to estimate the model, whereafter the parameters were used as to calculate compensated, uncompensated and expenditure elasticities.

1. INTRODUCTION

Various authors have estimated demand relations for South African 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.

According to Blanciforti *et al* (1986) there are basically two approaches when trying to estimate demand systems. The first approach starts with a utility function that satisfies certain axioms of choice. Demand functions are then 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 one starts with an arbitrary demand system and then imposes restrictions on the system. This approach corresponds with micro- and macro economic theories to a much closer extend than the first approach and is therefore the method applied in this study.

2. METHODOLOGICAL FRAMEWORK

During the last two decades, consumer demand analysis has moved toward system-wide approaches. Numerous algebraic specifications of demand systems now exist, including the linear and quadratic expenditure systems,

[1] *Department of Agricultural Economics, University of the Free State, Bloemfontein.*

the Working model, the Rotterdam model, Translog models and the Almost Ideal Demand System (AIDS).

Two of the aforementioned, the AIDS and Rotterdam models, have gained prominence in demand analysis, especially in the field of agricultural economics. The AIDS, developed by Angus Deaton and John Meulbauer in the late 1970s can be seen as the most recent major breakthrough in demand system generations. Alston & 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 this statement, 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.

Buse (1994) further 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 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).

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. Firstly, the Linear Approximate version of the AIDS (LA/AIDS) is relatively easy to estimate and interpret. It satisfies the axioms of choice exactly. Thirdly, 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 in the fourth place derived from a specific cost function and therefore corresponds with a well-defined preference structure, which is convenient for welfare analysis. Fifthly, homogeneity and symmetry restrictions depend only on the estimated parameters and are therefore easily tested and/or imposed. In the sixth place, the AIDS provides also an arbitrary first-order approximation to any demand system. Seventhly, it aggregates perfectly across consumers without invoking parallel linear Engel curves and finally, it has a functional form which is consistent with known household-budget data.

2.1 The theoretical specification of the AIDS model

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

$$w_{it} = \alpha_i + \sum_{j}^{n} \gamma_{ij} \ln p_{jt} + \beta_i \ln(X_t / P_t) + u_{it} \qquad \text{i= 1,…,n} \tag{1}$$

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:

$$\ln P_t = \alpha_0 + \sum \alpha_j \ln p_j + \frac{1}{2} \sum_{i}^{n} \sum_{j}^{n} \gamma_{it} \ln p_{it} \ln p_{jt} \qquad t = 1,…,T \tag{2}$$

This price index makes the system non-linear, which normally complicates the estimation process. In order to overcome this problem, Deaton and Meulbauer (1980) suggest using another linear price index.

2.2 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 (1991); 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 reasonably well to the AIDS model (Asche & 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:

$$LogP = \sum_{i=1}^{n} w_{i,t} \log p_{i,t} \tag{3}$$

Eales & 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 ($w_{i,\ t\text{-}1}$) for Equation 3. Replacement of equation 3 with the lagged shares into Equation 1 yields the LA/AIDS, given by:

$$w_{it} = \alpha_i + \sum_{j}^{n} \gamma_{ij} \ln p_{jt} + \beta_i (LnX - \sum_{i=1}^{n} w_{i,t-1} \ln p_{i.t}) + u_{i,t} \tag{4}$$

Equation 4 can then be applied to the empirical data, where after the anticipated parameters can be used to calculate the required elasticities. The formulas required for these calculations are provided in the next section.

2.3 Price and expenditure elasticities

Compensated and uncompensated elasticities were calculated by using the formulas reported by Jung (2000) as shown in Equations 5 and 6 respectively:

$$e_{i,t}^{*} = e_{it} + \bar{w} + \hat{\beta}\left(\frac{\bar{w}_j}{\bar{w}_i}\right) = -\delta + \frac{\hat{\gamma}_{it}}{\bar{w}_t} + \bar{w}_j \quad \text{I,J=1,2,....,N.} \tag{5}$$

$$e_{i,t} = -\delta + \frac{\hat{\gamma}_{it}}{\bar{w}_t} - \hat{\beta}_t\left(\frac{\bar{w}_j}{\bar{w}_i}\right) \tag{6}$$

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

The formula used to calculate the expenditure elasticities can be written as:

$$\eta_i = 1 + \frac{\hat{\beta}_i}{\bar{w}_i} \tag{7}$$

3. DATA USED AND STATISTICAL PROPERTIES OF THE VARIABLES

3.1 The data

Annual time series data from the NDA (2003) were used to calculate the variables for the LA/AIDS model specified in Equation 4. Before the model was estimated, the variables were subjected to four statistical tests, including: Univariate properties of the data, structural breaks, separability and exogeneity of the expenditure variable.

3.2 Univariate properties of the variables

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. When 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 a few. The test that is applied in this study is the DF and an extension thereof called the Augmented Dickey-Fuller (ADF). All variables to be employed in the LA/AIDS model are integrated of the order 1, I(1), i.e. stationary in the first difference form.

Tests for co-integration did not yield any unique long run relationship between the variables and the LA/AIDS was therefore estimated in first differenced format by means of a RSUR.

3.3 Tests for structural breaks

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 (2003), 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 (Equation 4) was examined; the structural breaks being the period(s) where the residuals exceeded two standard errors. In the case of the beef share equation, the residuals vary between the 2 standard error bands, thus no indication of structural breaks.

The residual for the chicken share equation during 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. Two intercept dummy variables were introduced, which solved the problem.

The residual plot of the pork share equation showed that a structural break occurred during 1991/1992 in the pork industry. The explanation of the break in practical terms is not as 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, the per capita consumption of pig meat increased dramatically, and a major drop in producer prices was experienced, attributable mainly to a relative oversupply of pork during this period. As in the case of the chicken share equation, an intercept dummy variable introduced for 1991/1992 in the pork share equation solved the problem.

Lastly, the residual plot of the mutton share equation pointed towards two possible structural breaks, namely during 1972 and 1980. A possible explanation for this is that 1972/73 can be characterized 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. Similar to chicken and pork, intercept dummy variables introduced accounted for the breaks.

3.4 Two-stage budgeting and separability

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. 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 for example). 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 & 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 must be independent of the value of any variable in any other group.

Two tests for weak separability, including an F and Likelihood ratio version, failed to reject the null hypothesis of weak seperability, confirming that the four meat products are separable from other commodities, and should be modelled together.

3.5 Exogeneity of the expenditure variable

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

$$m = T(\theta * - \theta)'[Var(\theta *) - Var(\theta)]^{-1}(\theta * - \theta), \quad (8)$$

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

To test for exogeneity, θ is the SUR estimator, and θ^* 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 or efficient, whereas the 3SLS estimators are inefficient but consistent.

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% significance level, indicating that the null hypothesis, namely that the expenditure variable is exogenous, can be accepted (see Table 1).

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 1: Exogeneity test of the expenditure variable

	Calculated test statistic	DF	Critical Value (α=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

4. EMPIRICAL RESULTS

4.1 Properties of the demand function

The properties of a demand function, which can be tested or used to restrict an empirical 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 semi definite matrix.

In order to adhere to the adding-up property of demand functions, one of the four share equations (mutton in this case) were dropped for estimation purposes and the restriction was imposed in the system.

Table 2: 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 symmetry restriction, in turn, restricts cross price derivatives of the demand functions to be identical. Table 2 reports the Wald test statistics for homogeneity and symmetry tests by means of the unrestricted SUR estimation procedure in Micro Fit 4.1. It is clear that for all 3 the share equations, the probability of making an error when rejecting any of the null hypotheses (homogeneity and symmetry) is greater than at least 14%. It can be concluded that price parameters are homogeneous of degree zero and symmetric in the

South African LA/AIDS meat demand model and that the restrictions can be enforced in the estimation process.

The homogeneity restriction implies that the sum of the nominal price parameters in each share equation adds up to 0. 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 & Meulbauer, 1999**)**. Practically the homogeneity restriction implies that if all prices and income are multiplied by a positive constant, θ, the quantity demanded must remain unchanged. The null hypothesis is thus that the prices are homogeneous of degree zero, whereas the alternative hypothesis indicates non-homogeneous prices.

With the three sets of demand restrictions satisfied as well as the structural break accounted for, the restricted LA/AIDS model can be estimated by means of a Restricted Seemingly Unrelated Regression (RSUR). The RSUR parameter estimates and corresponding t-ratios for the LA/AIDS demand model are reported in Table 3.

Table 3: Parameter estimates of the LA/AIDS model

		Dependent variables			
		Beef	**Chicken**	**Pork**	**Mutton**
Explanatory variables	Beef	0.172 *(4.13)****			
	Chicken	-0.1 *(-3.85)****	0.151 *(5.95)****		
	Pork	-.007 *(-0.84)*	-.0316 *(-5.06)****	0.422 *(7.35)****	
	Mutton	-.067 *(-2.49)***	-.020 *(-0.92)*	-0.004 *(-0.48)*	0.091
	Expenditure	0.115 *(1.38)**	-0.141 *(-2.4)***	-0.004 *(-0.22)*	0.029
	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%.

4.2 Compensated elasticities

Compensated or Hicksian elasticities are reduced to contain only price effects, and are thus compensated for the effect of a change in the relative income on demand. By using the parameter estimates in Table 4 and Formula 5, the compensated own and cross-price elasticities, as well as the corresponding t–ratios, were calculated at their sample means and are shown in Table 4.

Table 4: Compensated elasticities of South African meat products, LA/AIDS model (1970 – 2000)

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

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

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% 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% 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.

4.3 Uncompensated elasticities

Uncompensated or Marshallian price elasticities contain both the income and price effects. Similar to the compensated own and cross-price elasticities, the uncompensated own and cross-price elasticities were calculated at their sample means by using Equation 6, and are shown in Table 5. 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% level. The uncompensated own price elasticities of beef (-0.75), chicken (-0.35), pork (-0.37) and mutton (-0.47) are significantly lower compared with some of the previous estimates for meat in South Africa.

Table 5: Uncompensated elasticities of South African meat products, LA/AIDS model (1970 – 2000)

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

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

4.4 Expenditure elasticities

The calculated expenditure elasticities (by using equation 7) for South African meat products, which are all positive and statistically significant at the 5% level, indicate that all meat can be considered as normal to luxury goods, as expected *a priori* (see Table 6).

Table 6: Expenditure elasticities of South African meat products, LA/AIDS model (1970 – 2000)

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

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

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 than 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.

5. CONCLUSION

In this study a system-wide demand approach was used to estimate the demand relations for meat in South Africa. Similar, in a sense, to previous estimates like Badurally-Adam (1998), the calculated expenditure elasticities show that beef and mutton can be considered luxury products whilst pork is close to being considered a luxury product. Chicken, on the other hand, turned out to be the only product to be classified as a necessity in this budget share group.

In terms of the compensated and uncompensated own and cross price elasticities, the LA/AIDS estimates are significantly lower (more inelastic) compared to previous estimates for meat in South Africa. This can be ascribed to two reasons. Firstly, that the estimates were for different time periods and secondly, probably the main reason, is the estimation technique. The LA/AIDS estimates compare better to estimates of other countries like the US, UK and Korea, for example, with similar time periods and techniques.

REFERENCES

ASCHE F & WESSELS CR (1997). On price indices in the Almost Ideal Demand System. *American Journal of Agricultural Economics* 79:1182–1185.

ALEMU ZG, OOTHUIZEN LK & VAN SCHALKWYK HD (2003). Contribution of agriculture in the Ethiopian economy: A time-varying parameter approach. *Agrekon* 42(1):29–48.

ALSTON JM & CHALFANT JA (1993). The Silence of the Lambdas: A test of the Almost Ideal and Rotterdam models. *American Journal of Agricultural Economics* 75:304–313.

ALSTON JM, FOSTER TK & GREEN RD (1994). Estimating elasticities with the linear approximate almost ideal demand system: Some Monte Carlo results. *The Review of Economics and Statistics* 76(2):351–356.

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

BLANCIFORTI L, GREEN R & KING GA (1986). *US consumer behaviour over the post-war period: An Almost Ideal Demand System analysis*. Giannini Foundation Monograph, Number 40, August. Department of Agricultural and Resource Economics, University of California, Davis.

BUSE A (1994). Evaluating the linearized Almost Ideal Demand System. *American Journal of Agricultural Economics* 74:781-793.

DEATON A & MUELBAUER J (1980). An Almost Ideal Demand System. *The American Economic Review* 70(3):312–326.

DEATON A & MUELBAUER J (1999). *Economics and consumer behaviour*. Cambridge: University Press.

EALES JS & UNNEVEHR LJ (1988). Demand for beef and chicken products: Seperability and structural change. *American Journal of Agricultural Economics* 70(3):521-532.

EALES JS & UNNEVEHR LJ (1994). The inverse almost ideal demand system. *European Economic Review* 38:101–115.

EDGERTON DL (1993). On the estimation of separable demand models. *Journal of Agricultural and Resource Economics* 18(2):62–79.

FEDDERKE J (2000). *Advanced time series analysis*. Lecture notes, University of the Witwatersrand, Johannesburg.

GLEWWE P (2001). *Consumption Economics. - APEC 8401*. Lecture notes. University of Minnesota, St Paul.

GREEN R & ALSTON JM (1991). Elasticities in AIDS models: A clarification and extensions. *American Journal of Agricultural Economics* 73:874-875.

HAHN W (1994). Elasticities in the AIDS models. Comment. *American Journal of Agricultural Economics* 76:972-977.

JUNG J (2000). *Econometric estimation of demand for meat and fish products in Korea.* Unpublished MS thesis. Fargo: North Dakota State University.

LAFRANCE JT (1991). When is expenditure "exogenous" in separable demand models. *Western Journal of Agricultural Economics* 16(1):49–62.

MOSCHINI G (1995). Units of measurement and the stone index in demand system estimation. *American Journal of Agricultural Economics* 77:63-68.

MOSCHINI G, MORO D & GREEN R (1994). Maintaining and testing separability in demand systems. *American Journal of Agricultural Economics* 76:61-73.

NATIONAL DEPARTMENT OF AGRICULTURE (NDA) (2003). *Abstracts of Agricultural Statistics*. RSA.

NEWBOLD P, RAYNER T & KELLARD N (2000). Long run drift, co-movement and persistence in real wheat and maize prices. *Journal of Agricultural Economics* 51(1):106–121.

PASHARDES P (1993). Bias in estimating the Almost Ideal Demand System with the Stone Index Approximation. *Economic Journal* 103:908–915.

PHLIPS L (1974). *Applied consumption analysis*. Amsterdam: North-Holland Publishing Company.