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MEASURING THE DEMAND RESPONSE TO ADVERTISING IN THE AUSTRALIAN MEAT INDUSTRY

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Abstract

Many commentators believe that greater health consciousness has caused a shift in demand away from red meat. To try to counteract this trend the Australian meat industry has undertaken generic advertising. There are differences of opinion regarding the effectiveness of this advertising. Ball and Dewbre (1989) found a significant, plausible response in consumption to generic advertising undertaken by the Australian Meat and Livestock Corporation (AMLC) and the Australian Pork Corporation (APC). Their study used simple linear models. This study explores the implications of using flexible functional forms in complete demand systems for the measurement of the demand response to advertising in the Australian meat industry. From the models estimated there seems little ground for believing that advertising has affected consumption in the manner which Ball and Dewbre (1989) claimed. The results from this study show clearly that empirical measurement of the effects of advertising vary with choice about functional form of demand equations.

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1 Background

In recent years Australians have consumed less red meat and more white meat, whilst the total consumption of meat has remained relatively stable. As shown in Figure 1, on a per capita basis, beef consumption has declined from 62.2 kg in 1977 to 38.6 kg in 1988. Over the same period, chicken consumption increased from 16.0 kg to 22.3 kg, the consumption of pork increased from 12.9 kg to 17.5 kg whilst the consumption of lamb remained stable at 15.0 kg. These changes in consumption have been attributed by many commentators to an increased health consciousness on the part of consumers. Some believe that information regarding the hazards of high cholesterol and its association with red meat has caused consumer attitudes towards red meat to change. That is, consumers are eating more white meat such as chicken and less red meat in the belief that the former is 'healthier' than the latter.

To try to counteract this trend the red meat industry has undertaken expenditure on generic advertising funded by producers through levies on production. Expenditure on advertising by the industry in nominal terms have risen from less than $1m in 1975-76 to over $17m in 1987-88. Over this period the Australian Meat and Livestock Corporation (AMLC) increased its expenditure on beef and lamb advertising from $0.8m to $13m and the Australian Pork Corporation (APC) increased its expenditures on pork advertising from $0.2m to $4m. Real advertising expenditure by the AMLC and APC over the same period are shown in Figure 2.

Ball and Dewbre (1989), in a quantitative study, found that the advertising campaigns undertaken by the AMLC and APC had increased meat demand. Moreover, they found that the returns from the increase in demand outweighed the advertising expenditure, thereby making the expenditures profitable. These findings imply that advertising expenditures have caused changes in attitudes and preferences in relation to meat. In other words, there is an implication that the advertising campaigns have been successful and, consequently, have caused a structural change in the demand for meat by causing consumers' preferences to change.

Some studies aimed at testing for structural change in meat demand in Australia have been unable to find significant structural change. Results from both nonparametric tests (see Chalfant and Alston 1988) and parametric tests (see Alston and Chalfant 1991; Martin and Porter 1985) suggest there has been no significant structural change. Alston and Chalfant (1991) suggest that findings of structural change in meat demand can be attributed to the use of unduly simple functional forms.

2 Objective

The model Ball and Dewbre (1989) used was linear, a functional form which is highly restrictive. There is evidence that findings of structural change in meat demand are less likely when flexible functional forms are used than when more restrictive functional forms are used. However, studies which have been based on the former have not included variables reflecting advertising. The contribution of this study is to remedy this deficiency. In particular, the presence of structural change caused by successful advertising campaigns is tested using flexible functional form models which are consistent with economic theory and which incorporate advertising expenditures as explanatory variables.

Four flexible functional forms are estimated using a demand systems approach, namely the Almost Ideal Demand System (AIDS), the Linear Approximate Almost Ideal Demand System (LA/AIDS) and two versions of the Rotterdam model, to test the null hypothesis. This approach is different to previous studies which typically only investigate one functional form without considering whether an alternative functional form produces the same results. Although flexible functional forms may provide good approximations to unknown models, they do not eliminate the possibility of misspecification. Alston and Chalfant (1991), using a single data set, showed results can vary considerably even when estimating flexible functional forms. Hence, more than one model is investigated here to see if consistent conclusions can be obtained using different models.

The null and alternative hypotheses to be tested in this study are:

> **H_0: Advertising expenditures by the AMLC and APC have not affected consumption of beef, lamb and pork.**
>
> **H_1: Advertising expenditures by the AMLC and APC have affected consumption of beef, lamb and pork.**

The implication of not rejecting the null hypothesis is that current levels of expenditure on advertising should be reviewed with the view to reducing them or, alternatively, that advertising strategies should be revised. A rejection of the null hypothesis in favour of H_1 would provide the motive for further research aimed at more precise measurement of the benefits and costs associated with advertising than has been the case in past studies.

3 Integrating advertising into demand theory

With the increased use of generic advertising as a marketing tool, increasing attention has been given to how advertising should be integrated into demand theory and how advertising affects consumption. Not surprisingly, opinions differ. Most studies rely upon econometric techniques which themselves have been subject to controversy with respect to issues such as choice of functional form and data quality.

One line of argument which is particularly relevant to this study began with Galbraith (1958) who argued that advertising could bring about changes in consumer's tastes. Schmalansee (1972) was also of this view and argues that advertising cannot be incorporated into neoclassical demand theory because that theory is derived on the assumption of constant tastes. Stigler and Becker (1977) argued in direct opposition to the views of Galbraith and Schmalansee, stating that " it is neither necessary nor useful to attribute to advertising the function of changing tastes. A consumer may indirectly receive utility from a market good, yet the utility depends not only on the quantity of the good but also the consumer's knowledge of its true or alleged properties" (p. 84). Stigler and Becker point out how the complex notion of information can be measured and how it can be integrated into the theory of demand while preserving stability of tastes. They used a household production function which was augmented by advertising, human capital and other exogenous factors. That is, households combine units of information, human capital and market goods, subject to constraints from the household production function, to create utility.

Verma (1980) and Cox (1989), using a similar household production function model, also support the view that advertising augments the utility of a commodity through information. According to Verma (1980), because advertising is produced by the firm and not households, advertising plays the role of an exogenous shift variable in the household's production function for information and, ultimately, goods and services.

Recent work by Berndt (1991) provides support for the views of Stigler and Becker (1977) and the modelling approach of Verma (1980). Berndt argues that Verma's model is the most appropriate to date for incorporating advertising effects into a theoretically consistent framework which allows for the possibility that advertising does not necessarily change preferences. Verma's approach implies that, in empirical models of consumer demand, advertising variables should be included along with the usual price and income variables. This is because advertising acts as a shift variable in an underlying household production function model in that it affects the level of information available and, ultimately, causes shifts in the demand for goods and services.

4 An economic model

To test the null hypothesis, advertising must be included in the neoclassical demand model. The model attributable to Stigler and Becker (1977), Verma (1980) and Cox (1989) seems the most appropriate for this purpose. In this model an individual's behaviour is characterised as being the result of maximising a utility function represented by:

$$\text{Utility} = U\,(z_1, z_2, z_3, \ldots, z_n)$$

subject to

$$z_i = z_i\,(q_i, a, b); \text{ and}$$

$$m = \sum_{i=1}^{n} p_i q_i$$

where z_i = the household production function for good i ;

a = a vector of the amount of advertising expenditure; and

b = a vector of exogenous factors (e.g., seasonality and trends).

Substituting for z_i to make the optimisation problem more explicit gives:

$$\text{MAX } U\,(z_1\,(q_1, a, b), z_2\,(q_2, a, b), \ldots, z_n\,(q_n, a, b))$$

subject to

$$m = \sum_{i=1}^{n} p_i q_i.$$

This simplifies to:

$$\text{MAX } U(q_1, q_2, \ldots q_n\,;\, a, b)$$

subject to

$$m = \sum_{i=1}^{n} p_i q_i$$

The Lagrangean function for this maximisation problem is:

$$L = F(q_1, q_2, \ldots, q_n; a, b) + \lambda(m - \sum_{i=1}^{n} p_i q_i)$$

Setting all partial derivatives equal to zero and solving the resulting set of simultaneous equations results in demand functions of the form:

$$q_i = f(p_1, p_2, p_3, \ldots, p_n, m, a, b)$$

This function is the general form of the Marshallian demand function for a commodity where the quantity demanded is a function of prices and incomes and exogenous demand shifters, a and b.

5 Specification issues

The neoclassical model of utility maximisation subject to a budget constraint implies restrictions on the relationships among various demand elasticities. These restrictions can be utilised in empirical work to ensure that parameter estimates are consistent with theory and to reduce the number of parameters which need to be estimated. The restrictions of adding-up, homogeneity and symmetry are imposed as a maintained hypothesis in this study.

Another important decision was that a number of flexible demand system models should be estimated because the authors had insufficient *a priori* knowledge to make a choice among the alternatives available. It was thought desirable to determine how sensitive results are to model choice. Admittedly, this way of proceeding is at odds with one school of thought about what constitutes 'good' applied econometrics: namely, the analyst should, through careful a priori reasoning, determine how the underlying economic forces work and then choose the most appropriate model.

Also, it was decided that weak separability could be applied to consumers' behaviour. The weakly separable meat group was assumed to consist of beef, lamb, pork and chicken. Although it seems logical that mutton and fish should also be in the group, they had to be excluded because of lack of data. This is acknowledged as a shortcoming of the specification, but an unavoidable one. An implication of this specification choice is that the appropriate 'income' variable to be used in the models is total expenditure on the weakly separable meat group rather than expenditure on all goods. Alston and Chalfant (1987) found that estimates derived using expenditure on the meat group are likely to be more reliable than estimates derived using expenditure on all goods but they were unable to establish whether separability should be imposed.

Finally, there is little *a priori* information to guide one in modelling the 'decay' effect from a given 'dose' of advertising. Following Aviphant, Lee and Brown (1988), it was decided to account for this decay effect by using a weighted moving average of past advertising expenditures, with the weights declining through time. An advantage of using a weighted moving average variable is that it can be incorporated readily into a demand system framework. After some experimentation it was decided that the length of the lag should be four quarters with the weights declining linearly from 0.4 for advertising expenditure in the current quarter to 0.1 for advertising expenditure undertaken three quarters ago. Also, since some previous studies of meat demand (e.g., Alston and Chalfant 1991) have found seasonality and time trends to be statistically significant in Australian meat demand, quarterly dummy variables to capture seasonality and a linear time trend were included in each equation in all systems.

6 The theoretical models

To begin with, static forms of the models estimated are presented and then ways to incorporate time trends, seasonality and advertising variables are considered so that the theoretical properties of adding-up, homogeneity and symmetry are preserved. The following notation is used in describing the models:

q_i = per capita consumption of meat type i;
p_i = per unit retail price of meat type i deflated by the Consumer Price Index (CPI);
Y = per capita disposable income deflated by the CPI;
m = total expenditure per capita on the four types of meat (i.e., $m = \sum_{i=1}^{n} p_i q_i$);
s_i = the share of meat type i in per capita expenditure on meat ($s_i = p_i q_i/m$);
T = a linear time trend;
QD_k = quarterly dummies (k=1, 2 or 3);
AMLC = the weighted average of real advertising expenditures by the AMLC;
APC = the weighted average of real advertising expenditures by the APC;
i, j = 1 for beef, 2 for pork, 3 for lamb, 4 for chicken;
c = 1 for AMLC, 2 for APC; and
n = is the number of different meats.

The flexible functional form models estimated in this study are:

Almost Ideal Demand System (AIDS)

$$s_i = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} \ln p_j + \beta_i \ln(m/P)$$

$$\ln P = \alpha_0 + \sum_{k=1}^{n} \alpha_k \ln p_k + \frac{1}{2} \sum_{k=1}^{n} \sum_{j=1}^{n} \gamma_{ij} \ln p_k \ln p_j$$

Linear Approximate Almost Ideal Demand System (LA/AIDS)

$$s_i = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} \ln p_j + \beta_i \ln(m/P)$$

$$\ln P = \ln P^* = \sum_{k=1}^{n} s_k \ln p_k$$

Rotterdam Model (Absolute Price Version)

$$\bar{s}_i \ \Delta \ln q_i = \sum_{j=1}^{n} \gamma_{ij} \Delta \ln p_j + \beta_i \Delta \ln \hat{Q}$$

$$\Delta \ln \hat{Q} = \sum_{k=1}^{n} \bar{s}_k \ \Delta \ln q_k,$$

$$\bar{s}_{i,t} = 0.5(s_{i,t} + s_{i,t-1})$$

A decision was made to also estimate a linear model identical to that estimated by Ball and Dewbre (1989). This was mainly for comparative purposes. The model estimated was:

$$q_i = \alpha_{0i} + \tau_i T + \sum_{k=1}^{3} \theta_{ik} QD_k + \sum_{j=1}^{n} \gamma_{ij} \ln p_j + \beta_i Y + \phi_{ic}(AMLC) + \delta_{ic}(APC)$$

where variables are as previously defined except that advertising does not enter in the form of a weighted moving average of real advertising expenditures. Following Ball and Dewbre (1989) advertising entered in the form of current expenditures.

7 Demand shifters in flexible functional form models

In order to test the null hypothesis in this study, the demand shifters for advertising, time trends and seasonality must be incorporated in such a way so as to preserve the integrability properties of the models. The properties of demand equations are defined using parametric restrictions. To preserve these properties it is sensible to incorporate the demand shift variables as modifications of the existing parameters and continue to insist that the restrictions are maintained. In the case of the AIDS and LA/AIDS model any of the parameters could be modified. This study considers only one alternative of incorporating the demand shift variables as modifications of the intercept (α_i's). This approach is preferred since its interpretation seems more consistent with the economic model. The restrictions of adding-up, homogeneity and symmetry are preserved on the modified parameters, ensuring that the augmented model is compatible with theory. The intercept in the LA/AIDS and AIDS model thus becomes:

$$\alpha_i = \alpha_{0i} + \tau_i T + \sum_{k=1}^{3} \theta_{ik} QD_k + \phi_{ic}(AMLC) + \delta_{ic}(APC)$$

where α_{0i}, τ_i, θ_{ik}, ϕ_{ic} and δ_{ic} are unknown parameters.

As far as the authors are aware, no previous demand study has been undertaken in which an AIDS model incorporating advertising is estimated. This is because of the need for non-linear estimation which results from the use of the AIDS price index (see Deaton and

Muellbauer 1980). The non-linear estimation is slow and is sensitive to starting values, leading most authors to estimate the LA/AIDS model instead. The LA/AIDS model differs from the AIDS model in that the former is a linear approximation to the latter. This model is not integrable. Despite this, it is investigated here because it is the model used in most other studies (e.g., Green, Carman and McManus 1991) and the estimates of the LA/AIDS model can be compared with the estimates of the AIDS model.

Advertising variables are incorporated into the Rotterdam model as separate variables. This is in contrast to Duffy (1987) who incorporated advertising into the Rotterdam model as a modification of the marginal utilities or effectively as a deflator of real price which was also done by Green *et al* with the LA/AIDS model. Again this alternative is chosen because its interpretation is more consistent with the economic model that advertising is one of the arguments of the demand function where;

$$q_i = f(p_1, p_2, \ldots\ldots p_n, m, AMLC, APC)$$

Taking the logarithmic differential yields:

$$d\ln q_i = \sum_{j=1}^{n} \gamma_{ij} d\ln p_j + \eta_{im} d\ln \hat{Q} + \phi_{ic} d\ln(AMLC) + \delta_{ic} d\ln(APC)$$

After making the usual transformations the following equation is derived (expressed in discrete time):

$$\bar{s}_i \Delta\ln q_i = \sum_{j=1}^{n} \gamma_{ij} \Delta\ln p_j + \beta_i \Delta\ln \hat{Q} + \phi_{ic} \bar{s}_i \Delta\ln(AMLC) + \delta_{ic} \bar{s}_i \Delta\ln(APC)$$

To represent seasonality and time trends, the same method used by Alston and Chalfant (1991) was adopted where four quarterly intercept dummy variables are included in each equation with a restriction that the coefficients sum to zero within the equation. Also, an intercept term is included in each to account for any trends in the term $\bar{s}_i \Delta\ln q_i$. The complete augmented Absolute Price version of the Rotterdam model is then:

$$\bar{s}_i \Delta\ln q_i = \tau_i + \sum_{k=1}^{4} \theta_{ik} QD_k + \phi_{ic} \bar{s}_i \Delta\ln(AMLC) + \delta_{ic} \bar{s}_i \Delta\ln(APC) + \sum_{j=1}^{n} \gamma_{ij} \Delta\ln P_j + \beta_i \Delta\ln \hat{Q}$$

This model will be referred to as Rotdam (SS), where SS denotes 'smaller sample'. In the Rotterdam model, unlike the AIDS and LA/AIDS models, the advertising variable enters in logarithmic form. This is problematic if advertising observations are zero in any time period in that the logarithm of zero is not defined. In this study the observations for APC advertising have zero value for the first five quarters (i.e., from 1977(1) to 1978(1)). Hence, these observations were omitted reducing the sample size when estimating Rotdam(SS).

Cox (1989) also encountered a problem with zero observations for advertising expenditures in trying to estimate a Rotterdam model. But his solution to the problem may be referred to as an 'ad-hoc fix-up' in that he chose not to take the logarithm of advertising expenditures before differencing. Using Cox's approach, the Absolute Price version of the Rotterdam model incorporating advertising, time trends and seasonality becomes:

$$\bar{s}_i \Delta \ln q_i = \tau_i + \sum_{k=1}^{4} \theta_{ik} QD_k + \phi_{ic} \Delta(AMLC) + \delta_{ic} \Delta(APC) + \sum_{j=1}^{n} \gamma_{ij} \Delta \ln P_j + \beta_i \Delta \ln \hat{Q}$$

and is referred to here as as the Rotdam(Cox) model. The model implies that advertising enters the demand function exponentially. This is contrary to what would be expected if advertising expenditures have a 'decay effect' (advertising would be expected to have diminishing returns). This model is estimated to see how an unrealistic assumption and specification effects the hypothesis test.

8 Estimation

All the flexible functional form demand systems were estimated using the non-linear option in Shazam (Version 6.2). The share equations for chicken were not estimated to avoid the problem of a singular matrix. Coefficients for the chicken equation were obtained from adding-up and symmetry restrictions.

Because the estimation procedure is iterative, it was necessary to ensure that a global maximum was reached in each case. This was achieved by using different starting values for the parameters and by using a convergence criterion of 1E-10. Except for the AIDS model, estimates were corrected for first-order autocorrelation using the AUTO command in Shazam. Convergence problems occurred when this was attempted for the AIDS estimates (recall the earlier discussion about possible problems of convergence associated with the AIDS model).

In the case of the linear model, the estimation procedures chosen were identical to those used by Ball and Dewbre (1989). In particular, variables were normalised about their means so that coefficients could be interpreted as elasticities and the Seemingly Unrelated Regressions option in Shazam (Version 6.2) was used for estimation.

To facilitate hypothesis testing a 'nested' procedure was used in which all models were estimated with and without the advertising variables included. This allowed likelihood ratio tests to be used to test the null hypothesis.

The price and quantity data used in the estimation of the AIDS, LA/AIDS and Rotterdam models were identical to those used by Alston and Chalfant (1991). They consist of 48 quarterly observations on retail-level prices and consumption for the different meats covering the period 1977(1) to 1988(4). The prices are in dollars per kilogram and were deflated by the Consumer Price Index (CPI). Quantities consumed are in kilograms per capita.

The advertising data are identical to those used by Ball and Dewbre (1989). Ball and Dewbre derived these data by summing real expenditures on advertising for each medium (television, radio and print), where the deflator was an index for the cost of each medium prepared by the Television Bureau of Advertising. These data were used in this study to construct a weighted moving average advertising variable for each quarter from 1977(1) to 1988(4) where the units are in thousands of dollars. One limitation of the advertising data is that it was not possible to separate the advertising expenditures on lamb and beef. Hence, total advertising expenditures by the AMLC had to be used in the equations for beef, lamb and pork.

The linear model was estimated with alternative data sets. One set corresponds exactly to the data set published by Ball and Dewbre (1989) except for the price data. Unfortunately, the published Ball and Dewbre data set did not include prices. Hence, the price data used by Alston and Chalfant described above were used. Also, the quarterly data used by Ball and Dewbre were published as kilograms per capita rounded to one decimal place. Figures for pork consumption, for example, were of the order of 0.9 to 1.7. In the authors' view this constitutes 'heavy' rounding. Hence, a decision was made to also provide estimates for the linear models using Alston and Chalfant's quantity data. Doing so also allows for a comparison to be made between results from the flexible functional forms and the linear form using the same data set.

The parameters and test statistics are defined in Table 1. The results shown in Table 2 are for the linear model. Six sets of results are shown. Set 1 are the results published by Ball and Dewbre (1989). Set 2 are the results from using Ball and Dewbre's model specification but estimated using Ball and Dewbre's quantities and advertising data, and Alston and Chalfant price data (i.e., they are the results of trying to replicate Ball and Dewbre's). Set 3 are results from incorporating all time trends and seasonality variables into Ball and Dewbre's specification while Set 4 are results from including time trends and seasonality but excluding the advertising variables. These latter two sets of results are used in the formal hypothesis testing procedure. The final two sets, Set 5 and Set 6, are results from specifications corresponding to those underlying Set 3 and Set 4, respectively, but estimated using Alston and Chalfant's quantity and price data. They also are used in the formal hypothesis testing procedure (recall the discussion earlier about the extent of rounding in the quantity data used by Ball and Dewbre). All the regression coefficients shown in Table 2 can be interpreted as elasticities.

The results shown in Table 3 to 6 are for the AIDS, LA/AIDS and the two Rotterdam models. In Tables 3 and 4, estimated regression coefficients are shown for models excluding advertising variables and including advertising variables, respectively. Tables 5 and 6 contain, respectively, uncompensated demand elasticities computed from the results shown in Tables 3 and 4. Unlike the regression coefficients reported in Tables 3 and 4 for which there is little prior information to assess the credibility of the results, there is some prior information about elasticities so it was thought desirable to report these.

Following Alston and Chalfant (1991), elasticities were computed for each data point and the elasticities reported in Tables 5 and 6 are the means of these. While the predicted value of s_i (i.e., $\hat{s}_i$) was used in computing elasticities for the AIDS and LA/AIDS models, it was necessary to use the mean value of $\bar{s}_i$ (recall $\bar{s}_{i,t} = 0.5(s_{i,t}+s_{i,t-1})$) in computing the elasticities for the Rotdam(Cox) and Rotdam(SS) models because of the difficulty in obtaining estimates of $\hat{s}_i$ from these models. This difficulty was due to the fact that the dependent variable in the Rotterdam model is $\bar{s}_i \Delta \ln q_i$, rather than $\bar{s}_i$. The final set of results reported in this section relate to the likelihood ratio test of the null hypothesis and are shown in Table 7.

9 Coefficients and elasticities

There are no priors about the value of the coefficients shown in Tables 3 and 4 except that they should be statistically significant. Priors do exist, however, with respect to elasticities, with the meats expected to be normal goods having positive expenditure elasticities ($\eta_{im}>0$), negative own-price elasticities ($\eta_{ij}<0$ for i=j), and (generally) positive cross-price elasticities ($\eta_{ij}>0$ when $i \neq j$) indicating that the meats are gross substitutes. The advertising elasticities in the beef and lamb equations should be positive with respect to the AMLC expenditures and negative with respect to APC expenditures ($\eta_{b,AMLC}>0$; $\eta_{b,APC}<0$; $\eta_{l,AMLC}>0$; and $\eta_{l,APC}<0$). The advertising elasticities in the pork equations should be negative with respect to AMLC expenditure and positive with respect to APC expenditure ($\eta_{p,AMLC}<0$; and $\eta_{p,APC}>0$).

9.1 The linear models

The linear models were estimated in an effort to replicate Ball and Dewbre (1989) results and so that the linear estimates could be compared with estimates from the flexible functional forms with cross-equation restrictions imposed. Although the results obtained by Ball and Dewbre could not be replicated exactly because the prices used in their analysis were not published, similar estimates were obtained using their quantity and advertising data in conjunction with Alston and Chalfant (1991) price data. As shown in Table 2, when comparing Set 1 with Set 2 there is little difference in terms of sign and magnitude, except that the estimates for η_{bl}, η_{bp}, η_{pc} and $\eta_{l,AMLC}$ are opposite in sign. However none of these coefficients were statistically significant.

There is no apparent reason why Ball and Dewbre did not include D_1, D_2 and T in the lamb equation and why T was excluded from the pork equation. Omission of relevant variables causes results to be biased. Models were estimated including those variables (Set 3), and it was found that the omitted seasonal dummies in the lamb equation were statistically significant. Including these variables shows clearly how specification effects results. Inclusion of these previously omitted variables means that the beef and lamb income elasticities are no longer statistically significant. Ball and Dewbre's (1989) claims about both AMLC and APC advertising being statistically significant based on t-tests must be questionable in a model that is suspected of being misspecified

Generally speaking, the linear models gave estimates of elasticities which were a reasonable approximation to what would be expected from priors. Trends were found only in the beef equation whilst seasonality was almost always statistically significant. While the linear results seem plausible, other studies have found that unduly simple functional forms such as a linear form can lead to false inferences (see Alston and Chalfant 1991). Another disadvantage about the linear estimates is that they are not entirely consistent with economic theory in that they fail to satisfy integrability. Nor are cross-equation restrictions imposed in these models. However, the linear estimates serve as a comparison against the more theoretically-plausible flexible form demand systems. For this reason the linear model was estimated with and without advertising variables included using the Alston and Chalfant prices and quantities, with the results being shown as Set 5 and Set 6, respectively. The estimates for the linear models using the two different data sets produce similar own-price and cross-price elasticities. However, some of the signs for the advertising elasticities, and the advertising elasticities that were individually statistically significant, differ between the two models. For example $\eta_{p,AMLC}$ is positive in Set 5 and negative in Set 3, $\eta_{b,AMLC}$ is statistically significant in Set 5 but not in Set 3, whilst $\eta_{p,APC}$ is statistically significant in Set 3 but not in Set 5. These differences might be due to the differences between the Ball and Dewbre quantities and the Alston and Chalfant quantities. The former, as mentioned earlier, are rounded to one decimal place while the Alston and Chalfant quantity data are to four decimal places.

9.2 The flexible functional form models

The flexible functional form models were estimated with and without advertising so that likelihood ratio tests could be used to test the null hypothesis using the Alston and Chalfant prices and quantities. The two sets of results are discussed in turn.

9.2.1 Advertising variables excluded

Table 3 shows the results of models that were estimated without advertising variables. In the LA/AIDS model most of the γ_{ij} and β_i coefficients, as well as trends and seasonality, were statistically significant. The AIDS model, however, had insignificant γ_{ij} coefficients but, as in the LA/AIDS model, trends, seasonality and all the β_i coefficients were significant. In comparing the estimates from the LA/AIDS and AIDS models, it must be remembered that the AIDS model was not corrected for first-order autocorrelation but the LA/AIDS model was, and this correction generally improved the statistical significance of the estimates. The elasticities in Table 5 are generally plausible and reasonably consistent across models. All the own-price elasticities are negative and the expenditure elasticities are positive (except η_c) as priors would suggest. Most of the cross-price elasticities are positive, implying that the respective meats are gross substitutes, except for η_{bl}, η_{bp}, η_{bc} and η_{cp} which are negative.

These negative cross-price elasticities might be rationalised using the distinction between gross and net substitutes (complements) as explained by Nicholson (1985, p. 141). Two commodities may be gross complements in the sense of having negative uncompensated cross-price elasticities even though they are net substitutes in the sense of having positive compensated cross-price elasticities. Uncompensated elasticities reflect responses to price changes when money incomes are not adjusted (i.e., compensated) to 'offset' the price change. Hence, they incorporate both the substitution and income effects of the price change. They are the elasticities reported in this study. Compensated price elasticities, on the other hand, only reflect the substitution effect of a price change. Based on the substitution effect alone, the authors' expectation is that any two meats under investigation in this study are substitutes (i.e., their compensated cross-price elasticities are positive) and the negative signs for uncompensated cross-price elasticities are due to income effects outweighing substitution effects.

Comparing the LA/AIDS model elasticities with the AIDS model elasticities in Table 5, it could be said that the LA/AIDS model is a good approximation to the AIDS model with these data. Encouragingly, the estimated elasticities of the AIDS model are similar to an AIDS model estimated by Alston and Chalfant (1991) using the same data set but a longer sample size. This is reassuring because of the difficulties involved in getting the AIDS model to converge and the sensitivity of results to choices of starting values.

The Rotdam(SS) and the Rotdam(Cox) models estimated without advertising are identical specifications except that the Rotdam(SS) is estimated with a smaller sample size (1978:2 to 1988:4). As shown in Table 3, the coefficients are similar with all the β_i and most of the γ_{ij} and seasonality coefficients being statistically significant. However, trends were not found to be statistically significant in either model. The Rotterdam model elasticities in Table 5 are similar for both models and plausible, and they are also very close to the AIDS and LA/AIDS elasticities. Again, the estimates are comparable to those obtained in the Alston and Chalfant (1991) study.

9.2.2 *Advertising variables included*

The estimates of all four flexible functional form demand systems with advertising variables included are shown in Table 4. The estimates appear not to have changed dramatically with the inclusion of advertising. The coefficient of ϕ_{11} was individually statistically significant in all models except Rotdam(Cox) and ϕ_{31} was individually statistically significant in the AIDS model.

Unlike the Ball and Dewbre (1989) elasticities, which were all consistent with priors with respect to sign, the signs of $\eta_{b,APC}$ and $\eta_{l,AMLC}$ are inconsistent with priors in some of the flexible form models in Table 6. Interestingly, only the Rotdam(Cox) model, in which advertising enters with the increasing returns characteristic, produced advertising elasticities that are consistent with priors in all cases.

9.3 Linear versus flexible forms

For brevity, the comparison between the results for linear and flexible forms will be confined to a comparison between Ball and Dewbre's results (Set 1) and those obtained from the Rotdam(SS) model. The latter model was preferred because it had the most statistically significant coefficients among the various flexible form models estimated. The AIDS and LA/AIDS models were not chosen because other studies have shown with Monte Carlo work that these models are likely to find trends when they are not present and the same may occur when investigating advertising, whilst the Rotdam(Cox) model was not chosen because it had the unlikely increasing returns to advertising characteristic.

Comparing advertising elasticities, only $\eta_{b,AMLC}$ was statistically significant in the Rotdam(SS) model (the advertising coefficients for Rotdam(SS) in Table 4 are in fact elasticities) while both $\eta_{b,AMLC}$ and $\eta_{p,APC}$ were statistically significant in the Ball and Dewbre estimates. From the Rotdam(SS) estimates, a one per cent increase in beef advertising expenditure by the AMLC will cause a 0.0163 per cent increase in beef demand. Ball and Dewbre's estimate of $\eta_{b,AMLC}$ found the effect would be twice that with demand increasing by 0.037 per cent from a one per cent increase in advertising expenditures by the AMLC. When considering the AMLC expenditure effects on lamb demand, the Rotdam(SS) model estimates become inconsistent with priors, indicating that a one per cent increase in expenditure causes a 0.0153 decline in lamb consumption. Further, if APC expenditures increased by one per cent, the demand for lamb would increase by 0.0124 per cent. Ball and Dewbre estimated the same increases in expenditures to cause a 0.009 per cent increase in the demand for lamb and a 0.008 per cent decrease in the demand for lamb, respectively. From these comparisons, and ignoring the differences in sign for the effects on lamb, on balance the linear model used by Ball and Dewbre (1989) estimated advertising elasticities that were twice the magnitude of the elasticities estimated in the more theoretically-plausible flexible models.

10 Interpretation of hypothesis tests

It is not easy to draw conclusions regarding the null hypothesis from the results shown in Table 7. The two linear models lead to opposite conclusions, the AIDS and LA/AIDS models lead one to reject the null hypothesis while the two Rotterdam models lead one to accept the null hypothesis.

These results lend strong support to the findings of Alston and Chalfant (1991), namely, that results are affected by functional form and the restrictions imposed. For example, when advertising variables were incorporated into a Rotterdam model in the way of implying increasing returns (i.e., the Rotdam(Cox)) they were statistically significant at the 10 per cent level having a χ^2 value of 11.36, and the elasticities of advertising were of the right sign. In the Rotdam(SS) model where advertising entered more conventionally, it was not even significant at the 20 per cent level and the signs of $\eta_{l,AMLC}$ and $\eta_{l,APC}$ were inconsistent with priors. Interestingly, if this study had only investigated the LA/AIDS model or the AIDS model, the conclusions would have been that advertising had affected consumption. This demonstrates the sensitivity of results to model choice.

Misspecification cannot be ignored. Misspecified models can lead to false findings because of biased estimates. There is no reason for believing that any of the models estimated in this study are necessarily correct, that is, that they are a good approximation to the true data-generating mechanism. In theory, the linear models may be more restrictive than the more flexible models, but this does not imply that the flexible forms cannot be misspecified or that they are a good approximation to the true data generating mechanism. Interestingly, in most cases, the elasticities across the flexible models are similar in sign and magnitude. Furthermore, the estimates for the AIDS and Rotterdam models that did not include advertising are similar to the estimates of Alston and Chalfant (1991). But this does not mean the estimates are unbiased and that the likelihood ratio tests lead to a correct conclusion.

Monte Carlo experiments that are designed to examine how specifying the wrong model can lead to incorrect conclusions may offer some explanation of the varying results obtained in this study. Alston and Chalfant (1991) undertook some Monte Carlo experiments with the Rotterdam, LA/AIDS and AIDS models when testing for trends in meat demand. They were able to show that functional form errors can be responsible for false rejections. They found that the AIDS and LA/AIDS model were able to detect significant trends in data sets when trends did not in fact exist. They also found the Rotterdam model had a low frequency of false rejections when the model was misspecified and, when estimated with data generated from a Rotterdam model, they were only able to find significant trends 39 per cent of the time when they were in the true data generating mechanism. It is possible that similar findings may occur when testing for advertising effects as was found when testing for time trends. But this is only speculative and Monte Carlo experiments need to be performed using advertising variables before this reasoning can be confirmed.

11 Implications of the results

Producer contributions to generic advertising campaigns are aimed at expanding the total market for their commodity. A necessary condition for contributions to be considered to be well spent is that the advertising should bring about increased sales or increased revenue from existing sales. Determining whether this has been the case is difficult in a market where consumers income, price changes and changes in the quality of the commodity are all occurring. An attempt has been made in this study to determine to what extent changes in demand can be attributed to advertising. For the three instances where the null hypothesis was rejected (the B&D, AIDS and LA/AIDS models), the models may have been misspecified. Other studies have shown that, when misspecified, the AIDS and LA/AIDS models have a high frequency of making false rejections. Given this, on balance this study lends support to the notion that preferences have remained stable; that is, the necessary condition mentioned above has not been met. The elasticities of advertising in all models were found to be relatively small as compared to price and expenditure elasticities. Some may believe that this is evidence that advertising does not effect consumption greatly, and that prices and expenditures are the main determinants of consumption.

Even if it could be shown with certainty that advertising has affected sales positively, it still needs to be shown that advertising is profitable. Some authors (e.g., Nerlove and Waugh 1961) attempt to do this using the so called 'optimal advertising' ratio. This ratio depends on parameters such as the long-run own-price elasticity of demand and the long-run elasticity of demand with respect to advertising. An implication of the findings from this study is that estimates of these parameters are likely to be quite sensitive to model specification. Ball and Dewbre (1989) attempted to demonstrate that advertising by the AMLC and APC was profitable by simulating a model of meat marketing with and without advertising included and concluded that 'increases in either AMLC or APC advertising, in isolation, increase profits of the producers undertaking the advertising' (p. 20). However, this conclusion was reached with little attention being given as to how changes in model specification affects results. These authors' would not have drawn such a strong conclusion.

12 Conclusions

The principal objective of this study was to determine if advertising expenditures by the AMLC and APC had affected consumption of beef, lamb and pork. There are differences in opinion regarding the effectiveness of the meat advertising. Farmers, in particular, are concerned about the mounting costs of the campaigns. In this paper the implications of using flexible functional forms in complete demand systems for measurement of the demand response to advertising in the Australian meat industry were explored and some of the questions about whether advertising has affected consumption were addressed.

The results from the hypothesis tests were mixed. It is obvious that data, specification and assumptions about functional form and the restrictions imposed upon parameters affect inferences. However, on balance these results suggest that advertising is unlikely to have affected the demand for meat in Australia with preferences having remained stable. The results lend support to the view that variations in relative prices and total expenditures account for most of the changes in meat consumption patterns in Australia. Although this study could not determine conclusively whether or not advertising should be incorporated into demand equations, one thing that was consistent across models was that the elasticities for advertising were very small. This, in itself, does not suggest that advertising is unprofitable. However, the accuracy of studies which try to determine whether advertising is profitable and whether there are optimal levels of advertising expenditure, based on estimates of one functional form, should be viewed with caution.

It follows that farmers' concerns about the mounting costs of the advertising expenditures and their effectiveness seem warranted. Current levels of expenditures on advertising and advertising strategies should be reviewed. An important point to keep in mind is that funds spent by the AMLC and APC on advertising are funds that could be spent on research to improve the quality and value-added of the meats. Even if it were true that the revenue generated by advertising exceeds expenditures on advertising, it needs to be shown that the expenditure an advertising is more profitable than expenditure on research or any other endeavours before it can be concluded that producers are getting the best value from the levies they pay.

13 References

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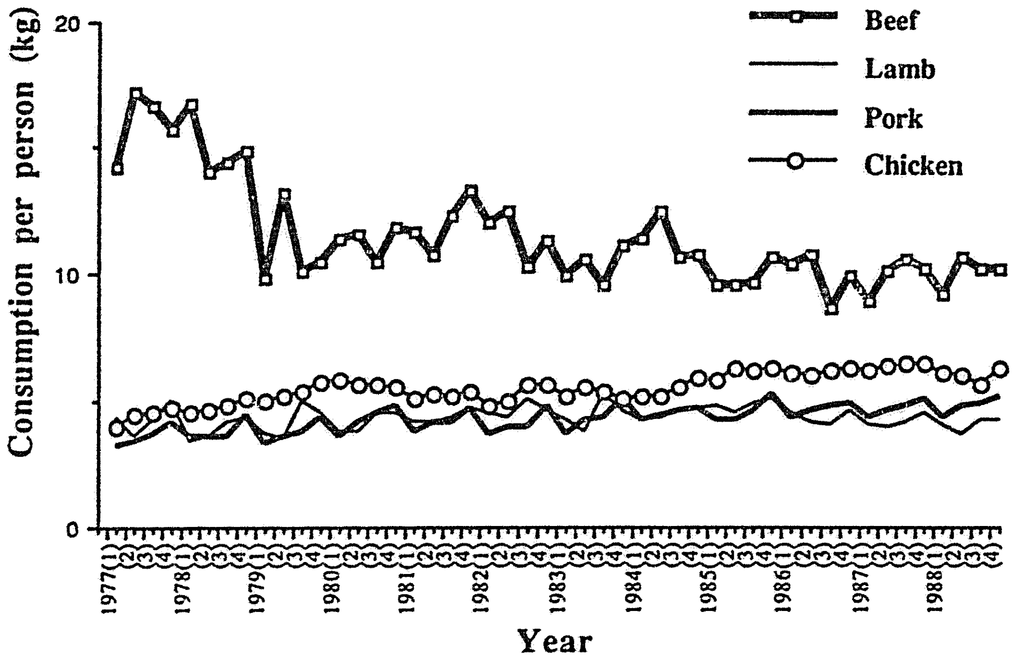
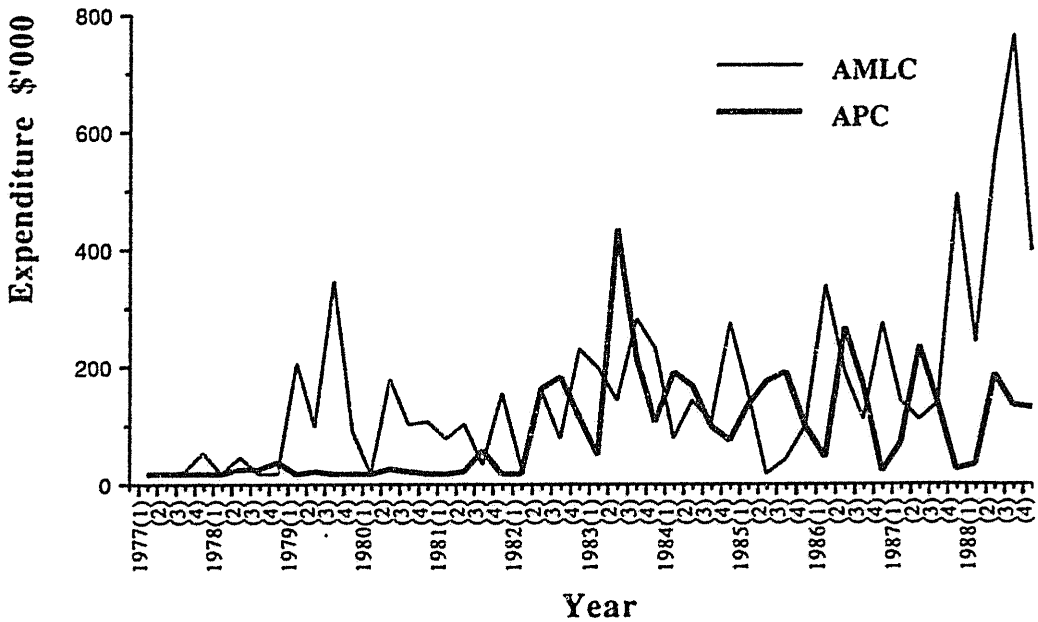


Source: Alston and Chalfant (1991)

Figure 1: Consumption of Beef, Lamb, Pork and Chicken.



Source: Ball and Dewbre (1989)

Figure 2: Real Advertising Expenditures

Table 1
Descriptions of Statistics and Coefficients

Statistics	Description
*	Denotes significantly different from zero at 5 per cent significance level;
#	Denotes derived from adding-up;
LL	Log-likelihood;
DW	Durbin Watson statistic (i = 1 for beef, 2 for lamb and 3 for pork);
R_i^2	R-square statistic (i = 1 for beef, 2 for lamb and 3 for pork);
Rho	First order autocorrelation coefficient.

Coefficients	Definitions
α_i	Intercepts (i = 1 for beef, 2 for lamb and 3 for pork);
α_0	Intercept term in the price index for the AIDS model;
α_{0i}	Intercepts (i = 1 for beef, 2 for lamb and 3 for pork);
β_i	Expenditure coefficients (i = 1 for beef, 2 for lamb, 3 for pork and 4 for chicken);
γ_{ij}	Price coefficients (i, j = 1 for beef, 2 for lamb, 3 for pork and 4 for chicken);
τ_i	Coefficient for time trend (i = 1 for beef, 2 for lamb, 3 for pork and 4 for chicken);
θ_{ik}	Seasonality coefficients (k = 1, 2 or 3 for i=1 for beef, 2 for lamb and 3 for pork);
ϕ_{ic}	Advertising coefficients (i = b for beef, l for lamb and p for pork, c = 1 for AMLC);
δ_{ic}	Advertising coefficients (i = b for beef, l for lamb and p for pork, c = 2 for APC);
η_{ij}	Uncompensated price elasticity for good i w.r.t the price of good j (i,j = b for beef, l for lamb, p for pork and c for chicken);
η_i	Expenditure elasticity of demand for good (i = b for beef, l for lamb, p for pork and c for chicken); and
$\eta_{i,c}$	Advertising elasticities (i = b for beef, l for lamb and p for pork, c = 1 for AMLC and 2 for APC).

Table 2
Results for the Linear Model

	Set 1	Set 2	Set 3	Set 4	Set 5	Set 6
LL		213.68	218.70	212.03	251.30	246.33
DW_1	2.10	2.17	2.15	2.11	2.09	2.05
DW_2	2.29	2.02	2.32	2.23	2.32	2.26
DW_3	1.72	1.72	1.73	1.92	2.40	2.41
R_1^2	0.92	0.93	0.94	0.93	0.88	0.86
R_2^2	0.78	0.79	0.83	0.83	0.85	0.84
R_3^2	0.91	0.91	0.92	0.90	0.96	0.95
α_1	0.288	0.472	0.682	0.245	0.809	0.196
α_2	-0.393	-0.175	0.562	0.581	0.206	0.249
α_3	1.661*	1.200	1.087	1.486	1.241	1.275
η_b	1.972*	1.137*	0.859	1.085*	0.615	0.925
η_l	0.897*	0.686*	-0.318	-0.247	-0.004	0.018
η_p	0.370	0.507	0.873	0.343	0.438	0.318
η_{bb}	-0.953*	-0.797*	-0.820*	-0.909*	-0.688*	-0.813*
η_{bl}	0.126	-0.012	0.026	0.127	0.101	0.242
η_{bp}	-0.026	0.046	0.054	0.179	-0.267	-0.088
η_{bc}	0.266	0.376	0.399	0.452	0.578	0.657
η_{lb}	0.496*	0.672*	0.584*	0.594*	0.582*	0.594*
η_{ll}	-1.131*	-1.309*	-1.146*	-1.137*	-1.156*	-1.158*
η_{lp}	0.383	0.295	0.331	0.292	0.344	0.314
η_{lc}	0.737*	0.815*	0.908*	0.860*	0.950*	0.921*
η_{pb}	0.755*	0.678*	0.740*	0.795*	0.442*	0.440*
η_{pl}	-0.271	-0.117	-0.172	-0.316	0.108	0.084
η_{pp}	-1.599*	-1.546*	-1.640*	-1.615*	-1.070*	-1.036*
η_{pc}	-0.051	0.103	-0.008	0.126	-0.011	0.043
τ_1	-0.771*	-0.344*	-0.306*	-0.272*	-0.242	-0.192
τ_2			0.141	0.109	0.116	0.096
τ_3			-0.083	0.008	-0.051	-0.015
θ_{11}	0.253*	0.175*	0.140*	0.148*	0.127*	0.138*
θ_{12}	0.173*	0.128*	0.098*	0.099*	0.055	0.044
θ_{13}	0.207*	0.160*	0.138*	0.135*	0.114*	0.109*
θ_{21}			-0.125*	-0.116*	-0.093*	-0.089*
θ_{22}			-0.108*	-0.112*	-0.086*	-0.087*
θ_{23}	0.107*	0.100*	0.022	0.022	0.044	0.044
θ_{31}	0.158*	0.158*	0.202*	0.159*	-0.166*	-0.177*
θ_{32}	0.239*	0.205*	0.237*	0.259*	-0.151*	-0.146*
θ_{33}	0.262*	0.248*	0.272*	0.278*	-0.113*	-0.112*
$\eta_{b,AMLC}$	3.7E-02*	2.06E-02	2.05E-02		2.91E-02*	
$\eta_{l,AMLC}$	9.0E-03	-3.51E-03	-3.80E-03		-3.50E-03	
$\eta_{p,AMLC}$	-1.8E-02	-9.05E-03	-7.01E-03		2.13E-03	
$\eta_{b,APC}$	-4.0E-03	-7.63E-03	-7.40E-03		-9.79E-03	
$\eta_{l,APC}$	-8.0E-03	-6.67E-03	-6.20E-03		-2.82E-03	
$\eta_{p,APC}$	2.9E-02*	3.09E-02*	3.29E-02*		8.85E-03	

Table 3
Coefficients for Models Estimated Without Advertising Variables

	LA/AIDS	AIDS	ROTDAM (Cox)	ROTDAM (SS)
LL	528.42	529.44	506.56	460.345
Rho	0.26014*		-0.07289	-0.13818*
α_0		7.3698*		
α_{10}	-0.55796*	2.0301		
α_{20}	0.29663*	-0.1006		
α_{30}	0.77768*	-0.4950		
β_1	0.33616*	0.36292*	0.87061*	0.86759*
β_2	-0.04892*	-0.05922*	0.09698*	0.08786*
β_3	-0.17442*	-0.17030*	0.02399*	0.03526*
β_4	-0.11283#	-0.13340#	0.00841#	0.00929#
γ_{11}	0.08478*	0.66538	-0.15889*	-0.16792*
γ_{12}	0.02972*	-0.06990	0.12549*	0.11565*
γ_{13}	-0.04431*	-0.30947	0.04827	0.05052
γ_{14}	-0.07019#	-0.28601#	-0.01486#	0.00174#
γ_{22}	-0.04556*	-0.02649	-0.20170*	-0.18963*
γ_{23}	0.01711*	0.05385	0.06305*	0.06111*
γ_{24}	-0.00127#	0.04255#	0.01316#	0.01287#
γ_{33}	-0.01861	0.11266	-0.16536*	-0.14828*
γ_{34}	0.04581#	0.14295#	0.05404#	0.00366#
γ_{44}	0.02565#	0.10052#	-0.05235#	-0.05126#
τ_1	-1.69E-03*	-1.69E-03*	-1.67E-03	-3.47E-05
τ_2	-7.78E-05	-7.40E-05	-3.43E-04	5.10E-05
τ_3	9.71E-04*	9.68E-04*	9.04E-04	9.11E-04
τ_4	6.01E-03#	8.02E-04#	1.11E-03#	-6.93E-04#
θ_{11}	0.05835*	0.05994*	0.05896*	0.05819*
θ_{12}	0.04375*	0.04796*	-0.01616*	-0.01521*
θ_{13}	0.02487*	0.02481*	-0.02007*	-0.02126*
θ_{21}	-0.01014*	-0.00991*	-0.00916*	-0.00858*
θ_{22}	-0.00722*	-0.00836*	0.00354	0.00346
θ_{23}	0.00597*	0.00588*	0.01329*	0.01384*
θ_{31}	-0.04236*	-0.04224*	-0.04312*	-0.04369*
θ_{32}	-0.03382*	-0.03392*	0.00891*	0.00936*
θ_{33}	-0.02742*	-0.02649*	0.00647*	0.00640*

Table 4
Coefficients for Models Estimated With Advertising Variables

	LA/AIDS	AIDS	ROTDAM (Cox)	ROTDAM (SS)
LL	537.90	542.22	512.24	463.71
Rho	0.15576		-0.03346	-0.13185*
α_0		9.8030*		
α_{10}	-0.57457*	2.8652*		
α_{20}	0.31540*	-0.2254		
α_{30}	0.76791*	-0.8827		
β_1	0.34199*	0.35523*	0.85447*	0.86571*
β_2	-0.05473*	-0.05581*	0.10426*	0.08914*
β_3	-0.17187*	-0.16615*	0.02718	0.03479
β_4	-0.11539#	-0.13327#	0.01409#	0.01036#
γ_{11}	0.08048*	0.94798*	-0.18939*	-0.24752*
γ_{12}	0.02728*	-0.11202	0.13507*	0.14531*
γ_{13}	-0.04333*	-0.44475*	0.05292	0.07525
γ_{14}	-0.06444#	-0.39121#	0.00141#	0.02697#
γ_{22}	-0.04673*	-0.02187	-0.19884*	-0.20017*
γ_{23}	0.01904	0.07922*	0.06394*	0.04977*
γ_{24}	-0.01943#	0.05467#	-0.00016#	0.00509#
γ_{33}	-0.01747	0.17452	-0.16830*	-0.15103*
γ_{34}	0.06077#	0.19101#	0.05144#	0.02601#
γ_{44}	-0.01577#	0.14553#	-0.05268#	-0.05914#
τ_1	-2.22E-03*	-2.08E-03*	-1.71E-03	-1.20E-03
τ_2	4.98E-05	-4.68E-06	-5.11E-04	-2.78E-04
τ_3	1.03E-03*	9.60E-04*	8.40E-04	8.68E-04
τ_4	1.14E-03#	1.13E-03#	1.38E-03#	6.10E-04#
θ_{11}	0.06039*	0.06088*	0.05717*	0.05289*
θ_{12}	0.04587*	0.04903*	-0.01383*	-0.01015*
θ_{13}	0.02603*	0.02601*	-0.01865*	-0.01928*
θ_{21}	-0.01068*	-0.00995*	-0.00909*	-0.00631*
θ_{22}	-0.00748*	-0.00815*	0.00369	0.00160
θ_{23}	0.00614*	0.00585	0.01282*	0.01322*
θ_{31}	-0.04235*	-0.04206*	-0.04247*	-0.04146*
θ_{32}	-0.03439*	-0.03468*	0.00073*	0.00732*
θ_{33}	-0.02815*	-0.02783*	0.00627*	0.00547
ϕ_{11}	8.94E-05*	1.32E-04*	5.77E-05	1.63E-02*
ϕ_{21}	-1.46E-05	-1.94E-05	5.78E-06	-1.53E-02
ϕ_{31}	-2.05E-05	-3.89E-05*	-1.87E-05	-2.22E-02
δ_{12}	1.28E-05	5.09E-06	-7.41E-05	-9.26E-03
δ_{22}	-9.88E-06	-1.99E-06	-1.06E-05	1.24E-02
δ_{32}	1.99E-05	2.21E-05	4.04E-05	1.21E-02

Table 5

Uncompensated Price and Expenditure Elasticities for Models Estimated Without Advertising Variables

	LA/AIDS	AIDS	ROTDAM(Cox)	ROTDAM (SS)
Price				
η_{bb}	-1.175	-1.253	-1.178	-1.196
η_{bl}	-0.039	-0.048	-0.005	-0.024
η_{bp}	-0.209	-0.181	-0.226	-0.227
η_{bc}	-0.218	-0.210	-0.246	-0.216
η_{lb}	0.373	0.404	0.517	0.486
η_{ll}	-1.257	-1.227	-1.482	-1.388
η_{lp}	0.178	0.127	0.308	0.305
η_{lc}	0.034	0.094	0.005	0.011
η_{pb}	0.253	0.336	0.193	0.172
η_{pl}	0.226	0.173	0.321	0.297
η_{pp}	-0.923	-0.936	-0.916	-0.821
η_{pc}	0.359	0.320	0.275	0.171
η_{cp}	-0.081	0.053	-0.152	-0.024
η_{cl}	0.110	0.201	0.094	0.090
η_{cp}	0.519	0.494	0.415	0.274
η_{cc}	-0.690	-0.722	-0.422	-0.412
Expenditure				
η_{b}	1.641	1.692	1.685	1.698
η_{l}	0.671	0.602	0.666	0.603
η_{p}	0.085	0.106	0.129	0.187
η_{c}	0.132	-0.026	0.066	0.073

Table 6

Uncompensated Price, Expenditure and Advertising Elasticities for Models Estimated With Advertising Variables

	LA/AIDS	AIDS	ROTDAM (Cox)	ROTDAM (SS)
Price				
η_{bb}	-1.189	-1.301	-1.221	-1.350
η_{bl}	-0.046	-0.030	0.019	0.034
η_{bp}	-0.209	-0.150	-0.211	-0.178
η_{bc}	-0.208	-0.177	-0.210	-0.166
η_{lb}	0.378	0.411	0.556	0.685
η_{ll}	-1.260	-1.243	-1.469	-1.462
η_{lp}	0.071	0.153	0.305	0.225
η_{lc}	0.179	0.054	-0.092	-0.043
η_{pb}	0.252	0.360	0.209	0.305
η_{pl}	0.134	0.193	0.323	0.237
η_{pp}	-0.920	-0.966	-0.935	-0.835
η_{pc}	0.436	0.275	0.259	0.114
η_{cb}	-0.026	0.175	-0.047	0.170
η_{cl}	0.282	0.159	-0.018	0.028
η_{cp}	0.638	0.430	0.386	0.189
η_{cc}	-1.006	-0.738	-0.430	-0.466
Expenditure				
η_b	1.652	1.677	1.654	1.694
η_l	0.632	0.625	0.716	0.611
η_p	0.098	0.128	0.147	0.184
η_c	0.112	-0.026	0.111	0.081
Advertising				
$\eta_{b,AMLC}$	2.32E-02	3.43E-02	1.49E-02	1.63E-02
$\eta_{l,AMLC}$	-1.29E-02	-1.72E-02	5.11E-03	-1.53E-02
$\eta_{p,AMLC}$	-1.36E-02	-2.58E-02	-1.24E-02	-2.22E-02
$\eta_{b,APC}$	1.78E-03	7.11E-04	-1.02E-02	-9.26E-03
$\eta_{l,APC}$	-4.59E-03	-9.24E-04	-4.94E-03	1.24E-02
$\eta_{p,APC}$	6.96E-03	7.71E-03	1.42E-02	1.21E-02

Table 7
Likelihood Ratio Test [a]

Model	L_U	L_R	Test Statistic	Reject / Not Reject
B&D [b]	218.70	212.03	13.34*	Reject
A&C [c]	246.33	251.30	9.94	Not Reject
LA/AIDS	537.90	528.42	18.96*	Reject
AIDS	542.22	529.44	25.56*	Reject
ROTDAM(COX)	512.24	506.56	11.36	Not Reject
ROTDAM(SS)	463.71	460.34	6.74	Not Reject

Note: * denotes statistically significant at 5 per cent level

a The likelihood ratio (LR) test is a general procedure for testing nested hypotheses when both the restricted and unrestricted models have been estimated by maximum likelihood methods. The test is based on computing values of the maximised log-likelihood functions for both models. If the unrestricted maximum is close to the restricted maximum, this indicates that the restrictions should be favoured. However, if the difference is substantial, the restrictions are rejected. The LR is given by:

$$g = -2(L_R - L_U)$$

where L_U and L_R are values of the maximized log-likelihood functions for the unrestricted and restricted models, respectively. The H_0 to be tested, as described in Section 2, can be expressed as

$$H_0: \phi_{11} = \phi_{21} = \phi_{31} = \delta_{12} = \delta_{22} = \delta_{32} = 0$$

H_1: not all the ϕ_{ic} and δ_{ic} are zero.

Under H_0, that the restrictions are true, g has an approximate χ^2-distribution with degrees of freedom equal to the number of restrictions. Since there are 6 restrictions, the critical value at the 5 per cent significance level is 12.59. The restrictions are rejected if g is greater the 12.59.

b B&D denotes the linear model estimated using Ball and Dewbre (1989) quantities and the Alston and Chalfant (1991) prices. The tests were undertaken on estimates from Set 3 and Set 4.

c A&C denotes the linear model estimated using the Alston and Chalfant (1991) prices and quantities. The tests were undertaken on estimates from Set 5 and Set 6.