# An Almost Ideal Demand System Analysis of Fresh Fruit in Australia*

John Asafu-Adjaye and Wayne Ritter
Department of Economics
The University of Queensland
St. Lucia, Qld 4072

Various studies have been conducted on agricultural commodities in Australia. However, to date, none have taken a specific look at the demand characteristics of the fresh fruit market. Given the size of the fresh fruit market and the growing awareness of the health benefits of fruit consumption in Australia, this study is of interest. The study utilises the Almost Ideal Demand System (AIDS) model to examine demand for four categories of fresh fruit: oranges, apples, bananas and other fruit. The results suggest that each fruit type has no close substitutes. Within the fruits sub-group, oranges, apples and bananas tend to be necessities while 'other fruits' appear to be luxury items. From the tests of structural change, it is concluded that although changes in relative prices and total expenditure explain some of the observed variation in fresh fruit consumption, a great proportion of the changes in expenditure patterns over the past 25 years can be attributed to structural change in consumer preferences.

Key Words: Demand analysis, econometric analysis, fruit consumption.

## Introduction

A familiar saying is 'An apple a day keeps the doctor away'. It would be interesting to know what effect that little saying has had on the demand for apples over the years. Little is known of the demand characteristics of individual fresh fruits including apples and few empirical papers have been published on this topic. Food is generally considered to be a necessity with an income elasticity of demand of less than one. Presumably fresh fruit is also classed as a necessity. Another unknown is the extent to which different types of fruit are seen as substitutes. In an attempt to provide some answers, this paper examines the demand for fresh fruit in Australia.

The only comprehensive study that has looked specifically at fruit purchasing behaviour in Australia is *Consumer Study of the Fruit and Vegetable Market: 1990* carried out by the Horticultural Research and Development Corporation (1990). The

* Contributed Paper, 39th Australian Agricultural Economics Society Conference, The University of Western Australia, Perth, 14-16 February, 1995.

study interviewed 1,954 households in all capitals except Canberra and Darwin in 1990. The survey results suggest that most Australians consider fruit to be an important part of their diet. From the sample, 56 percent said that fresh fruit was an extremely important part of the diet, and 37 percent said that it was an important part of the diet. A high 74 percent said they were concerned about their health and as a consequence were increasing their intake of fruit.

In a study of the Victorian wholesale market for apples, Tunstall and Quilkey (1990) estimate a linear demand model which is combined with a linear programming formulation to model market behaviour. Weissel and Whittingham (1978) employ spectral analysis to examine price relationships for selected fruit and vegetables sold in different wholesale markets in Australia.

None of the above studies take a specific look at the demand characteristics of fresh fruit[1]. In this paper we employ static and dynamic AIDS models to analyse fresh fruit demand in Australia. To simplify the analysis, only the following four categories of fresh fruit are considered: oranges, apples, bananas, and other fresh fruits. Parametric tests are used to analyse the issue of structural change in demand for fresh fruit.

The paper is organised as follows. The next section discusses the specification of the AIDS model. This is followed by a description of the estimation and testing procedures, as well as the data sources. The penultimate section presents the empirical and elasticity estimates while the final section presents the conclusions.

## Model Specification

The AIDS model is derived, via duality concepts, from the flexible expenditure function known as the price-independent generalised logarithmic (PIGLOG) form

(Deaton and Muellbauer 1980). The expenditure function is defined as the minimum expenditure required to achieve a given level of utility at current prices. A basic assumption of the AIDS model is the weak separability of the utility function. This makes possible the two-stage maximisation procedure. In the first stage consumers optimally allocate income among broad category groups. In the second stage, they optimally allocate the budget for each category group amongst each of the commodities in that group. This implies that substitution and complementarity between individual items can occur within groups but not between groups. The consequence of this separability assumption for empirical analysis is that data is only required for the particular group under investigation.

It is generally assumed that the food group is weakly separable from other categories and within the food group, that the sub-group of meat is weakly separable from other food sub-groups. The assumption underlying the present analysis is that the fresh fruit sub-group is also weakly separable from other food sub-groups. Thus, to estimate the demand for individual fresh fruits using the AIDS model, data is only needed on the prices and consumption of fresh fruits.

The resulting demand functions are as follows:

$$(1) \qquad W_i = \alpha_i + \sum_j \gamma_{ij} lnP_j + \beta_i(\ln X - \ln P)$$

where

i,j = 1....n refers to the four fresh fruit groups; 1=oranges, 2=apples, 3=bananas and 4=other fruits;

Wi = budget share of the *i*th fruit;

X = total expenditure on the group of goods under investigation;

$p_j$ = price of the *j*th good in the group;

and P is a price index defined by:

(2) $$\ln P = \alpha_0 + \sum_i \ln p_i + \frac{1}{2}\sum_i \sum_j \gamma_{ij} \ln p_i \ln p_j$$

P is approximated by Stone's price index (Stone 1953) which is defined by

$$\ln P = \sum W_i \ln p_i$$

which yields a system linear in parameters. This version is known as the linear approximate AIDS (LA/AIDS) model. Studies have shown that estimates from the LA/AIDS do not differ significantly from the full AIDS model (Deaton and Muellbauer 1980, Anderson and Blundell 1983).

To be consistent with the fundamental postulates of economic theory certain conditions must hold in terms of parameter restrictions. The first is the adding-up restriction which requires that the sum of individual expenditures equals total expenditure. This is achieved in the AIDS model by the following restrictions:

(2a) $$\sum_i \alpha_i = 1 \quad \sum_i \beta_i = 0 \quad \sum_i \gamma_{ij} = 0$$

The second is the homogeneity restriction which specifies that a demand equation must be homogeneous of degree zero in incomes and prices. This means that if incomes and all prices were to increase by the same factor, then the quantity of each good consumed would be unaltered. This restriction is specified as:

(2b) $$\sum_j \gamma_{ij} = 0$$

The third restriction is referred to as Slutsky symmetry and assures consistency of choice on the part of the consumer:

(2c) $$\gamma_{ij} = \gamma_{ji}$$

Most applications of the AIDS models are static, implying that consumers adjust their optimal purchases instantaneously to changes in prices and income. This specification of the demand system ignores the features of habit persistence and likely dynamic behaviour in consumer demand. In some applications, dynamic features have been incorporated by means of approximations of AIDS in first difference form. In this study the dynamic element is incorporated by specifying an *ad hoc* dynamic cost function by introducing one-period lagged consumption levels, $q_{it-1}$ into the PIGLOG expenditure function[2].

$$(3)\quad \ln C(p,u,q_{it-1}) = \alpha_0 + \sum_i (\alpha_i + d_i q_{it-1})\ln p_i + \frac{1}{2}\sum_i \sum_j \gamma_{ij} \ln p_i \ln p_j + U\beta_0 \prod p_k^{\beta_k}$$

By Shephard's lemma:

$$(4)\quad \frac{\partial \ln C}{\partial \ln p_i} = S_i = \alpha_i^* + d_i q_{it-1} + \sum_j \gamma_{ij} \ln p_j + \beta_i U \beta_0 \prod p_k^{\beta_k}$$

Substituting ln C = ln X for the unobserved utility function, habit persistence can be incorporated leading to the following share equations:

$$(5)\quad S_i = \alpha_i^* + d_i q_{it-1} + \sum_j \gamma_{ij} \ln p_j + \beta_i (\ln X - \ln P)$$

The adding up restriction in the modified system requires the following conditions to hold:

$$(6)\quad \sum_i \alpha_i^* = 1 \quad \sum_i \beta_i = 0 \quad \sum_i \gamma_{ij} = 0$$

**Estimation and Testing Procedures**

To estimate the static AIDS model (Equation 1) and the dynamic version (Equation 5), an error term is added to both equations. Since the sum of expenditure shares equals unity, the variance-covariance matrix for the complete 4-good system is singular. Therefore estimation is carried out by deleting one equation in order to render the remaining (n-1) by (n-1) variance-covariance matrix non-singular. The resultant estimates are invariant with respect to the equation deleted (Barten 1969). If the residuals are not serially correlated, then the parameters of the deleted equation can be derived from the parameters of the included equations using the adding-up restrictions. The equation deleted in this analysis is the 'other fruits' equation. The procedure used to perform the estimation is the iterative, nonlinear seemingly unrelated regressions (SUR) procedure of SHAZAM (White et al. 1993).

Both restricted (i.e. with parameter restrictions imposed) and unrestricted versions of the static and dynamic AIDS models are estimated. According to consumer theory homogeneity, adding up and Slutsky symmetry conditions hold for rational consumers, thus non-rejection of these conditions is used as criteria for model selection.

To test the demand restrictions, likelihood ratio tests are performed. In applying the LR tests, Cashin (1991) points out that the LR test is biased in the testing of demand restrictions. Asymptotic test statistics tend to over-reject restrictions derived from utility theory when they are imposed on demand systems in finite samples. Therefore the appropriate test to use is the adjusted LR statistic given by $LR^* = ((T - k)/T)LR$ where T is the number of observations and k is the number of explanatory variables in each equation.

The classical test designed for structural change in linear regression models is not applicable in the case of non-linear equation systems. In this study we apply a procedure suggested by Andrews and Fair (1988)[see also Judge et al. 1985 and Chen and Veeman 1991]. In a test of structural change in a non-linear simultaneous equations system, the unknown parameter Q has the form $Q = (Q_1, Q_2)$, where the likelihood function for $t_1 = T_1, \ldots, -1$ depends only on $Q_1$ and the likelihood function for $t_2 = 1, \ldots T_2$ depends on $Q_2$. The likelihood-ratio equivalent test statistic is given by:

(7) $\lambda_{LR} = (T_1 + T_2)[\ln(L_u) - \ln(L_r)] \sim \chi^2_k$

where $T_1 + T_2 = T$ = sample size for the two subsample periods;

$L_u$ = sum of the log-likelihood functions of the unrestricted estimates $Q_1$ and $Q_2$ evaluated over the two periods $T_1$ and $T_2$, respectively;

$L_r$ = log-likelihood function of the restricted estimate Q for the entire sample period.

k = number of parameters restricted to be equal over the two periods $T_1$ and $T_2$.

To test the null hypothesis of structural stability implied by $Q_1=Q_2$, the whole data set is used to compute the restricted estimate of Q (i.e. $Q_1=Q_2$). The unrestricted estimates of $Q_1$ and $Q_2$ are then computed using data for the two subsample periods. In this study, the sample period is divided into approximately two periods: 1968/69 - 1978/79 for $Q_1$ and 1979/80 - 1991/92 for $Q_2$.

Two sets of structural change tests are performed. The first employs the Andrews-Fair LR-equivalent approach to test for structural stability of all the coefficients in the model. The second test involves using an intercept dummy variable to test for an exogenous shift in the demand curve in the two periods.

## Data Sources

Annual observations for the period 1968/69 to 1991/92 are used in the estimations. The years are crop years, i.e., from the first of April to the end of March. The ABS produces a series on fresh fruit consumption in Cat. No. 4306.0. However this series was not used because the consumption of fresh fruit also includes the consumption of fruit juice. The total domestic consumption of oranges and apples has been derived by ABARE by deducting exports and processing (including juicing) from total production. Because the ABS collects data on apples and pears later in the year after the crop is harvested, the production figures for these two fruits have been included in following crop year. It is assumed that all bananas produced in Australia are consumed domestically as fresh fruit. The 'other fruits' category consists of apricots, cherries, mangoes, melons, nectarines, other citrus, peaches, pears, pineapples, plums, strawberries and table grapes.

Per capita fresh fruit consumption is calculated from mean population data in ABS Cat. No. 3101.0. To give an idea of the quantities of fresh fruit consumed by the average Australian, Table 1 presents figures for annual per capita consumption of fresh fruit in Australia from 1968/69 to 1991/92. On a per capita basis, consumption of all fruit except 'other fruits' declined slightly over this period.

Retail prices for fresh fruit are not available for Australia. Wholesale prices have been used on the assumption of a constant mark-up for all fruits. The wholesale prices have been derived from data contained in BAE's Fruits, ABARE's Commodity Statistical Bulletins, and ABS's Cat. No. 5703.0. For most of the fruits, the price of fresh fruit is obtained by deducting the value of exports and the value of fruit for processing, where available, from the gross value of production. The two exceptions are apples and pears where the prices are the average of monthly Sydney wholesale prices from March to September (Source: ABARE: Commodity Statistical Bulletins). The fruit prices were deflated using the CPI figures from ABS Cat. No. 6401.0.

Table 1
Apparent annual per capita consumption of fresh fruit in Australia (kg)

| Year | Oranges | Apples | Bananas | Other | Total |
|---|---|---|---|---|---|
| 1968/69 | 13.4 | 15.0 | 8.9 | 16.1 | 53.4 |
| 1969/70 | 13.1 | 15.2 | 8.9 | 16.0 | 53.2 |
| 1970/71 | 14.5 | 13.1 | 8.7 | 17.1 | 53.4 |
| 1971/72 | 15.0 | 15.2 | 8.4 | 19.6 | 58.2 |
| 1972/73 | 12.2 | 14.0 | 8.0 | 20.3 | 54.5 |
| 1973/74 | 13.1 | 13.3 | 7.8 | 17.1 | 51.3 |
| 1974/75 | 11.8 | 12.8 | 7.3 | 14.3 | 46.2 |
| 1975/76 | 12.6 | 14.0 | 7.4 | 15.7 | 49.7 |
| 1976/77 | 10.9 | 10.0 | 8.2 | 15.8 | 44.9 |
| 1977/78 | 10.2 | 13.2 | 6.9 | 15.6 | 45.9 |
| 1978/79 | 10.1 | 11.6 | 7.9 | 15.8 | 45.4 |
| 1979/80 | 9.7 | 13.0 | 8.6 | 13.7 | 45.0 |
| 1980/81 | 9.7 | 11.8 | 8.4 | 14.9 | 44.8 |
| 1981/82 | 9.4 | 11.6 | 8.6 | 16.3 | 45.9 |
| 1982/83 | 8.4 | 12.8 | 9.2 | 17.2 | 47.6 |
| 1983/84 | 10.1 | 10.9 | 9.4 | 16.0 | 46.7 |
| 1984/85 | 9.6 | 12.0 | 9.3 | 17.3 | 48.2 |
| 1985/86 | 9.0 | 12.1 | 8.5 | 16.7 | 46.3 |
| 1986/87 | 10.8 | 10.8 | 10.0 | 18.0 | 49.6 |
| 1987/88 | 9.7 | 9.9 | 9.8 | 18.6 | 47.9 |
| 1988/89 | 10.9 | 8.3 | 11.7 | 20.5 | 51.4 |
| 1989/90 | 10.3 | 11.2 | 10.6 | 21.1 | 53.2 |
| 1990/91 | 8.5 | 12.0 | 9.6 | 22.0 | 52.0 |
| 1991/92 | 7.0 | 8.9 | 10.2 | 24.9 | 51.0 |

Sources: ABS: *Fruit, Australia*, Cat. Nos. 7303.0 and 7322.0; ABS: *Summary of Crops, Australia*, Cat. No. 7330.0; BAE: *Fruits* (various years); and ABARE: *Commodity Statistical Bulletin* (various years).

**Estimation Results and Elasticity Estimates**

The results of the likelihood-ratio tests for homogeneity and symmetry are presented in Table 2. The test statistic is LR = $-2(L_r - L_u)$, where $L_r$ is the maximum value of the log likelihood function with restrictions imposed and $L_u$ is the unrestricted value. The adjusted LR statistic is given by ((T-k)/T)LR, where T is the number of observations and k is the number of explanatory varaibles. The adjusted LR statistic exceeds the critical values for both the static and dynamic models. It is therefore concluded that the restrictions of homogeneity and symmetry can not be rejected in both specifications. Thus, it may be concluded that the specifications are consistent with the theory of consumer demand.

Table 2
Likelihood Ratio Tests for Homogeneity and Symmetry

| Model | $L_u^a$ | $L_r^b$ | Number of Restrictions | Adjusted LR Statistic[c] | Critical $(\chi^2_{.05})$ |
|---|---|---|---|---|---|
| Static AIDS | 211.29 | 204.58 | 10 | 10.07 | 18.31 |
| Dynamic AIDS | 207.88 | 187.51 | 10 | 5.09 | 18.31 |

a. $L_u$ = unrestricted loglikelihood value.
b. $L_r$ = restricted loglikelihood value.
c. Adjusted LR statistic = ((T-k)/T)LR; where LR=$-2(L_r-L_u)$; T=No. of observations and k=No. of explanatory variables.

Estimates of the structural parameters for both the static and dynamic AIDS models are presented on Table 3[3]. For the static model 9 out of 18 coefficients estimated are significantly different from zero at the 5 percent significant level, while for the dynamic model 10 out of the 21 coefficients estimated are significantly different from zero. The minimum budget shares, $\alpha_i$s, are less than one but greater than zero for both models, although in the static model the minimum budget share for 'other fruit' is negative.

Table 3
Parameter estimates for the static and dynamic AIDS models[*]

| | Static AIDS Model | | Dynamic AIDS Model | |
|---|---|---|---|---|
| Parameter | Estimate | Standard Error | Estimate | Standard Error |
| $\alpha_1$ | 0.2169 | 0.2577 | 0.1320 | 0.0348 |
| $d_1$ | - | - | 0.0008 | 0.0013 |
| $\gamma_{11}$ | 0.0787[a] | 0.0242 | 0.0714[a] | 0.2440 |
| $\gamma_{12}$ | -0.0302[a] | 0.0102 | -0.0460[a] | 0.0176 |
| $\gamma_{13}$ | -0.0381[a] | 0.0115 | -0.0299[a] | 0.0149 |
| $\gamma_{14}$ | -0.0103 | 0.0217 | 0.0044 | 0.0241 |
| $\beta_1$ | -0.0085 | 0.0666 | -0.0098 | 0.0079 |
| $\alpha_2$ | 0.3302 | 0.4022 | 0.2387[a] | 0.0564 |
| $d_2$ | - | - | -0.0024 | 0.0093 |
| $\gamma_{21}$ | -0.0302[a] | 0.0102 | -0.0460[a] | 0.0176 |
| $\gamma_{22}$ | 0.1145[a] | 0.0155 | 0.0948[a] | 0.0265 |
| $\gamma_{23}$ | -0.0162 | 0.0082 | 0.0077 | 0.0135 |
| $\gamma_{24}$ | -0.0680[a] | 0.0137 | -0.0565 | 0.0295 |
| $\beta_2$ | -0.0249 | 0.1037 | -0.0051 | 0.0207 |
| $\alpha_3$ | 0.4619 | 0.2187 | 0.2411[a] | 0.0366 |
| $d_3$ | - | - | 0.0005 | 0.0014 |
| $\gamma_{31}$ | -0.0381[a] | 0.0115 | -0.0299[a] | 0.0149 |
| $\gamma_{32}$ | -0.0162 | 0.0082 | 0.0077 | 0.0135 |
| $\gamma_{33}$ | 0.1140[a] | 0.0106 | 0.1140[a] | 0.0168 |
| $\gamma_{34}$ | -0.0596[a] | 0.0131 | -0.0918[a] | 0.0186 |
| $\beta_3$ | -0.0712 | 0.0565 | 0.0125 | 0.0069 |
| $\alpha_4$ | -0.0090 | - | 0.3882[a] | - |
| $d_4$ | - | - | 0.0011 | - |
| $\gamma_{41}$ | -0.0103 | 0.0217 | 0.0044 | 0.0241 |
| $\gamma_{42}$ | -0.0680[a] | 0.0137 | -0.0565 | 0.0295 |
| $\gamma_{43}$ | -0.0596[a] | 0.0131 | -0.0918[a] | 0.0186 |
| $\gamma_{44}$ | 0.1379 | - | 0.1439 | - |
| $\beta_4$ | 0.1046 | - | 0.0024 | - |

[a] Significant at the 5 percent level.
[*] Subscripts are as follows: 1=oranges, 2=apples, 3=bananas, 4=other fruit.

The $\beta_i$ coefficients measure the change in the *i*th budget share with respect to changes in real expenditure with all other factors held constant. An examination of the signs of the $\beta_i$ allows us to classify the different fruits as either luxuries or necessities. If $\beta_i$ is negative, the budget share decreases as real expenditure increases indicating that these fruits are necessities. On the other hand, a positive sign indicates that the fruits are luxuries. Thus, oranges, apples and bananas appear to be necessities while 'other fruits' appears to be luxuries. However the $\beta_i$'s are not significant therefore the above classifications are not conclusive. It is important to note that the $d_i$'s are all positive but not significant. This implies that habit persistence has a weak effect on consumer's budget share allocations for the various categories of fresh fruit.

Uncompensated price and expenditure elasticities are calculated using the static AIDS model. The group expenditure elasticities are given by:

(7) $$\eta_i = 1 + \frac{\beta_i}{W_i}$$

The Marshallian (uncompensated) own-price elasticities for the AIDS model are given by:

(8) $$\varepsilon_{ii} = -1 + \frac{\gamma_{ii}}{W_i} - \beta_i$$

The uncompensated cross-price elasticities are given by:

(9) $$\varepsilon_{ij} = \frac{\gamma_{ij}}{W_i} - \beta_i\left(\frac{W_j}{W_i}\right)$$

The Hicksian (compensated) price elasticities are given by:

(10) $$\delta_{ij} = \frac{\gamma_{ij}}{W_i} + Wj$$

Finally, the Allen partial elasticities of substitution are given by

(11) $$\sigma_{ii} = \frac{\sigma_{ii}}{W_i} = 1 + \frac{\gamma_{ii}}{W_i^2} - \frac{1}{W_i}$$

---

(12) $$\sigma_{ij} = \frac{\sigma_{ij}}{W_j} = 1 + \frac{\gamma_{ij}}{W_i W_j}$$

The uncompensated elasticities for the static AIDS models are reported in Table 4. These values were calculated at the mean of the budget share values for each fruit. The own-price elasticities are all of the correct sign and indicate that the demand for fresh fruit is inelastic. All of the cross-price elasticities are fairly small indicating that a rise in the price of one particular fruit has only a small effect on the demand for other fruits. Most of the cross-price elasticities are negative indicating that these fruits are gross complements. This is a somewhat unexpected result. The strongest complementary relationship is between apples and 'other fruits'.

The expenditure elasticities with respect to total expenditure on all fresh fruits are all positive, implying that all categories are normal goods[4]. Other fruits have expenditure elasticities greater than one and this classifies them as luxury items. Oranges, apples and bananas are classified as necessities. Bananas have the lowest expenditure elasticity with a value of 0.64.

Table 5 presents results for the Allen-Uzawa partial elasticities of subsitution in consumption. All the cross-price elasticities are positive, except for oranges and bananas[5]. These results imply that, as expected from theory, all pairs of fruit types are Hicks-Allen substitutes.

Table 4
Uncompensated price and expenditure elasticity estimates, Static Model

| | Orange s | Apple s | Banana s | Other Fruit | Expenditures |
|---|---|---|---|---|---|
| Oranges | -0.506 | -0.174 | -0.225 | -0.042 | 0.948 |
| Apples | -0.112 | -0.485 | -0.049 | -0.248 | 0.893 |
| Bananas | -0.136 | 0.002 | -0.344 | -0.156 | 0.635 |
| Other Fruit | -0.067 | -0.226 | -0.195 | -0.768 | 1.256 |

Table 5a
Allen-Uzawa Partial Elasticities of Substitution, Static AIDS Model

| | Oranges | Apples | Bananas | Other Fruit |
|---|---|---|---|---|
| Oranges | -2.174 | 0.203 | 0.206 | 0.845 |
| Apples | | -1.182 | 0.644 | 0.289 |
| Bananas | | | -1.129 | 0.253 |
| Other Fruit | | | | -0.620 |

Table 5b
Allen-Uzawa Partial Elasticities of Substitution, Dynamic Model

| | Oranges | Apples | Bananas | Other Fruit |
|---|---|---|---|---|
| Oranges | -2.4513 | -0.2140 | 0.0537 | 1.0663 |
| Apples | | -1.5436 | 1.1411 | -0.2416 |
| Bananas | | | -1.1293 | -1.4192 |
| Other Fruit | | | | -0.5840 |

The results of the tests of structural change are reported in Tables 6a and 6b. The hypothesis of no structural change in the complete set of parameters (Table 6a) is rejected at the 5 percent significant level. The results imply that there is a difference in all the parameters of the model before and after 1979. The null hypothesis of common intercepts for the two periods is tested separately and the results are reported in Table 6b. The dummy variable and intercept coefficients are significant for all the four fruit categories. The results show that the null hypothesis of no shift in demand before and after 1979 can be rejected. The signs of the dummy variables imply that after 1979, there was an expenditure shift away from apples and oranges towards bananas and other fruit. For example, the oranges intercept coefficient of 0.2653 and dummy variable coefficient of -0.0420 imply that the expenditure share for oranges declined by 16 percent, with prices and expenditure held constant. Likewise, expenditure shares for apples declined by 12 percent. On the other hand, the intercept coefficients of 0.1562 and .3348 for bananas and other fruit, and their corresponding dummy variable coefficients of 0.0407 and 0.0307 imply that expenditure shares for bananas and other fruit increased by 26 percent and 9 percent over the two periods, with prices and expenditure held constant. Actual changes in average expenditure shares over the periods 1968/69 - 1978/79 and 1979/80 - 1990/91 are: -15 percent for oranges, -5 percent for apples, 15 percent for bananas and 3 percent for other fruits.

Table 6a
Results of tests of structural stability, Dynamic Model

| Hypothesis | Number of restrictions | $L_r$ | $L_u$ | LR-like Test Statistic | Critical ($\chi^2_{.05}$) |
|---|---|---|---|---|---|
| No structural change in: | | | | | |
| all parameters | 18 | 187.51 | 236.85 | 1184.17 | 28.87 |

Table 6b
Results of tests of exogenous shift in demand, Dynamic Model*

| | Oranges | Apples | Bananas | Other Fruit |
|---|---|---|---|---|
| Intercept | 0.2653[a] (0.0384) | 0.3198[a] (0.0733) | 0.1562[a] (0.0289) | 0.3348[a] (0.0581) |
| Dummy Variable | -0.0420[a] (0.0086) | -0.0381[a] (0.0169) | 0.0407[a] (0.0066) | 0.0307[a] (0.0136) |

* Standard errors are in brackets.
[a] Significant at the 5 percent level.

## Conclusion

This analysis of the demand for fresh fruits using the AIDS model has provided, for the first time in Australia, information on the demand interrelationships between the most widely consumed types of fresh fruit. The particular fruits examined were oranges, apples, bananas with the remaining fresh fruits combined into one category called 'other fruits'. The own-price elasticities, which measure the sensitivity of quantity demanded to changes in price, were all very similar, varying from -0.41 to -0.47. One of the main determinants of these elasticity estimates is the closeness of substitutes. Since these estimates show that changes in the price of each fruit type do not have a strong effect on the quantity consumed, it is implied that each type does no have a close substitute, that is, each fruit type is fairly important to the majority of consumers who purchase fruit.

The estimated cross-price elasticities also suggest that each fruit type does not have close substitutes amongst the other fruit types. There appears to be a mild substitution effect between oranges and apples. The consumption of bananas appears to be relatively unaffected by price changes of any other fruit. Although generally small, most of the cross-price elasticities are negative, implying that most fresh fruits are compliments rather than substitutes. This result however may be influenced by annual supply characteristics of the Australian fruit market. The strongest complimentary relationship is between oranges and 'other fruits' with an elasticity in both directions of approximately -0.8.

In this analysis, the expenditure elasticity of demand measures the sensitivity of quantities consumed to changes in the budget allocation for fresh fruits. Of the four types, apples are the least sensitive to changes in expenditure with an elasticity of 0.127. The fruits in order of increasing sensitivity are apples, bananas, oranges and 'other fruits'. Within the fresh fruits sub-group, oranges and 'other fruits' appear as luxury items.

The null hypothesis of no structural change in the complete set of parameters is rejected. The likelihood-ratio equivalent test results suggest that there is a difference in some or all of the structural parameters before and after 1979. Dummy variable tests on the intercept coefficients suggest that expenditure shares for the various fresh fruit categories since 1979 are different from those in the preceding period. Since 1979, expenditure shares for oranges and apples have declined by 16 per cent and 12 percent, while those for bananas and other fruit have increased by 23 percent and 9 percent, holding prices and expenditure constant. On the basis of these findings, it is concluded that although changes in relative prices and total expenditure explain some of the variation in fresh fruit consumption, a fair amount of the observed changes in expenditure patterns over the past 25 years may be attributed to a structural change in consumer preferences. These changes may be associated with Australians' concern about their health and the need to eat wisely.

**Notes**

1. Meat demand has received a great deal of attention. See, for example, Alston and Chalfant (1987, 1991); Cashin (1991); Murray (1984); and Fisher (1979).

2. See, for example, Blanciforti and Green (1983). Other formulations use lagged expenditure levels (eg., see Ray 1984).

3. Autocorrelation was tested for using a procedure suggested by Berndt and Savin (1975). The results indicated the presence of autocorrelation. The final estimation was therefore carried out using an AR(1) model.

4. The unexpected results may be due to inadequacies in the data set, especially, that of bananas.

References

Alston, J.M. and J.A. Chalfant (1987), "Weak Separability and the Specification of Income in Demand Models, with Application to the Demand for Red Meats in Australia", *Australian Journal of Agricultural Economics* 31:1-15.

Alston, J.M. and J.A. Chalfant (1991), "Accounting for Changes in Demand", Invited paper, 35th Annual Conference, Australian Agricultural Economics Society, Armidale, February.

Anderson, G. and R. Blundell (1983), "Inference in Nonlinear Econometric Models with Structural Change", *The Review of Economic Studies* 55:615-40.

Andrews, D.W. and R.C. Fair (1988), "Inference in Nonlinear Econometric Models with Structural Change", *The Review of Economic Studies* 50:397-410.

Barten, A.P. (1969) "Maximum Likelihood Estimation of a Complete System of Demand Equations", *European Economic Review* 1:7-73.

Berndt, E.R and N.E. Savin (1975), "Estimation and Hypothesis testing in Singular Equation Systems with Autoregressive Disturbances", *Econometrica* 43:937-956.

Blanciforti, L. and R. Green (1983), "The Almost Ideal Demand System incorporating Habits: An Analysis of Expenditure on Food and Aggregate Commodity Groups", *Review of Economics and Statistics* 65:511-15.

Chen, P.Y. and M.M. Veeman (1991), "An Almost Ideal Demand System Analysis for Meats with Habit Formation and Structural Change", *Canadian Journal of Agricultural Economics* 39:223-235.

Cashin, P. (1991), "A Model of the Disaggregated Demand for Meat in Australia", *Australian Journal of Agricultural Economics*, 35(3), 263-283.

Deaton, A. and J. Muellbauer (1980), *Economic and Consumer Behaviour*, Cambridge University Press, Cambridge.

Fisher, B.S. (1979), "The Demand for Meat - An Example of an Incomplete Commodity Demand System", *Australian Journal of Agricultural Economics* 23:220-230.

Horticultural Research and Development Corporation (1990), *Consumer Study of the Fruit and Vegetable Market: 1990.*

Judge, G.G. et al. (1985), *The Theory and Practice of Econometrics*, 2nd ed. New York: John Wiley and Sons.

Murray, J. (1984), "Retail Demand for Meat in Australia: A Utility Theory Approach", *Economic Record* 60:45-56.

Phlips, L. (1983), *Applied Consumption Analysis*, North Holland, Amsterdam.

Ray, R. (1984), "A Dynamic Generalisation of the Almost Ideal Demand System", *Economic Letters* 14:235-239.

Stone, J.R.N. (1953), *The Measurement of Consumer's Expenditure and Behaviour in the United Kingdom, 1920-1938*, Vol. 1, Cambridge: Cambridge University Press

Tunstall, A.W. and J.J. Quilkey (1990), "Storage and Pricing of Apples: Some Empirical Evidence on the Structure of the Victorian Wholesale Market", *Australian Journal of Agricultural Economics* 34(3):280-291.

Weissel, D.A. and R.B. Whittingham (1978), *Price Information in the Fresh Fruit and vegetable Industries in Australia: An Exploratory Analysis of its Effectiveness of Transmission*, Occasional Paper No. 47, Bureau of Agricultural Economics, Canberra: Australian Government Publishing Service.

White, K.J., S.A. Haun, N.G. Horsman and S.D. Wong (1993) *SHAZAM: The Econometrics Computer Program*, New York: McGraw Hill.