DEMAND FOR MILK

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The consumer demand for fresh wholemilk in the Sydney region is analysed by single equation regressions of time series data. The explanatory variables of the regressions are income, milk price, advertising, seasonal dummies, age distribution of the population, consumption of substitutes and complements, and a dummy variable for strikes and flood interference with distribution. These variables are regressed on consumption per head using either weekly or quarterly data.

The weekly model was estimated with allowance for autocorrelated disturbances and the quarterly model was estimated using Almon polynomials to represent lag distributions of "real and/or money" variables. Results indicate that consumption is best explained by a relatively small set of variables, in particular—age distribution of the population and a lag distribution of real prices.

1 THE LITERATURE

In Australia, the demand for dairy products has been analysed by Drane and Edwards [8] and the demand for Canberra milk by Kinsman and Anderson [12]. There are also interesting discussions pertinent to milk consumption in Layton [13] and also Parish and Kerdpibule [18]. Some results on supply responses are available from Mules [14] and from Barbeler and Hamilton [2]. However, our knowledge of demand supply relationships in Australia and the degree of sophistication in techniques employed is far behind that of overseas. For a non-exhaustive sample see Goreaux (Europe) [10], National Food Survey Committee (U.K.) [16], Mundlak (Israel) [15], Cassels (U.S.A.) [3], George and King (U.S.A.) [9], Wold and Jureen (Sweden) [19], de Janvry, Bieri and Nurez (Argentina) [11], and Consejo de Bienester Rural (Venezuela) [5]. A table of price and income elasticities of demand for fluid wholemilk estimated by the above authors is shown below. As can be seen, the income elasticity ranges from $-0{\cdot}30$ to $0{\cdot}55$ (most often zero) and the own price elasticity is within the range $-0{\cdot}26$ to $-0{\cdot}45$ (excepting Venezuela).

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TABLE 1

Estimated Elasticity of Demand for Fluid Wholemilk in Various Countries

Source	Country	Price elasticity	Income elasticity	
Wold and Jureen..	Sweden ..	− 0·3	0·0	
Mundlak	Israel	− 0·266 to − 0·324	0·0 to 0·34	
Cassels	U.S.A. prewar	− 0·3 to − 0·45	n.a.	
N.F.S.C.	U.K.	n.a.	*Expenditure* 0·26 to 0·33	*Quantity* 0·24 to 0·31
Kinsman and Anderson ..	Canberra Australia ..	n.a.	0·35	
George and King..	U.S.A.	− 0·34	0·20 not significantly different from zero.	
C.B.R.	Venezuela ..	*Natural milk* − 0·72 to 0·77 *Pasteurized* − 0·59 to − 1·02	*Natural* 0·22 to 0·28	
			Pasteurized 0·48 to 0·55	
Goreaux	Europe and Nth America ..	n.a.	− 0·30 to 0·30	

2 DEMAND FACTORS

My hypothesis is that, *ceteris paribus*, consumption is inversely related to the price of milk, incomes of consumers, and the consumption of substitutes, and positively related to advertising and the consumption of complements. Changes in the age distribution of the population may cause both upward and downward variations in consumption. The reaction of milk consumption to these variables is not likely to be immediate. In particular it seems reasonable to suppose that consumers make adjustments over a period of time in response to changes in the price of milk and in their own incomes. Finally there is no *a priori* evidence to suggest the form of the relationship between the above variables. Hence I believe it is desirable to try a number of model specifications and see which best fits the data.

Some support for these tentative considerations is available from previous studies. The most thoroughly documented aspect is the response of consumption to price and income (*see* previous section for elasticities). The effect of age distribution on consumption has not been explicitly tested.

Drane and Edwards [8] took note of the fact that milk consumption was highly correlated with the crude birth rate. Other authors have noted a strong connection between size of household and milk consumption [12], [13], [19], and the National Food Survey Committee in England [16], has devoted considerable efforts in determining the differences in consumption habits occasioned by different household structures. Even less information is available on the interrelationships between the consumption of milk and other commodities. Layton [13] has shown that, among other things, light users of milk are more likely to use nail polish and heavy users more likely use plastic tableware and salami.

A more positive approach is followed by George and King [9] who construct a demand interrelationship matrix for U.S.A. food[1]. Of the commodities they analysed, only evaporated milk showed a strong interaction with milk consumption.

The cross-price elasticity of fresh milk for evaporated milk was 0·01 and of evaporated milk for fresh milk 0·21. This implies that the price of evaporated milk has almost no effect on the consumption of fresh milk but an increase of 100 per cent in the price of fresh milk would cause a 21 per cent increase in the quantity of evaporated milk consumed.

The effect of advertising on milk consumption is perhaps the poorest documented aspect. Layton [13] gives percentages of people surveyed who remembered advertising slogans, and some rankings by age, education and life-style of general attitudes towards milk. All the previous studies mentioned above used static models only and thus give no information on dynamic demand response to changes in variables. A preliminary inspection of weekly consumption data showed small dips in consumption immediately after price rises. Consumption returns to average levels after periods of 3 to 4 weeks. Thus an interesting hypothesis, which is not tested here due to computer programme limitations, is that consumers' initial reductions in demand in response to price rises are short-lived and do not affect long-term consumption patterns.

A notable feature of the N.S.W. milk market during the period under investigation is that supply is extremely elastic over the range of quantities demanded and prices paid. This is because the N.S.W. Dairy Industry Authority legally owns all the whole milk produced and exerts its authority to control distribution. Since the prices fixed have been higher than those at which farmers have been willing to produce the demanded quantities (since 1950) the Authority has always had a surplus which is diverted to be processed into other foods. Farmers have preferred to sell their milk as fresh milk, if possible, since the price paid is generally about double the "manufacturing milk" price. Thus the market can be considered as a monopoly where demand factors alone determine quantities traded at the given price.

3 SOME STATISTICAL CONSIDERATIONS

Dynamic response of consumption to changes in milk price and consumer's income is tested by the introduction of distributed lags of these variables into the regression relationship. In doing this, the problem arises of capturing the lag structure with as few parameters as possible in order to preserve degrees of freedom in estimation and to eliminate multicollinearity.

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[1] The elements of the matrix are own price elasticities, cross-price elasticities and income elasticities of demand. They show it is possible to obtain such information using only weak assumptions about neutrality and independence of desires for various commodities.

One solution is to use Almon interpolation polynomial techniques [1], [6]. This causes as many problems as it solves since there are a wide range of specifications which will give apparently satisfactory results with this approach. Since there is no unique method of relating parameters of the two sets we have an identification problem. There are a number of sets of polynomials which will correspond to the same distributed lag. Erroneous conclusions may be prevented to some extent if the distributed lag is estimated with as few restrictions as possible, before restricting the lag distribution to a theoretically attractive shape.

Thus the first estimate acts as a check upon the second. Almon variables were first estimated using no zero restrictions, and by varying the number of Almon variables an attempt was made to gauge the effect of truncation upon the estimated lag distribution. Zero restrictions were then applied on the assumption that the distributed lag effect of the corresponding variable is zero outside the range of the estimated polynomial.

Problems of multicollinearity and loss of degrees of freedom in this analysis caused by the large number of variables used and, in the case of age distribution data, by the fact that the five variables were linearly dependent, made it desirable to attempt to find a smaller set of variables which captured most of the variability in the data. It is possible to do this for sets of variables which are highly collinear by estimating "principal components" of these sets. Principal components are orthogonal linear combinations of the larger set of variables which individually and sequentially exhibit the maximum possible variance that such a linear combination can contain. Generally, a few principal components will capture most of the variation in the larger set of data. Thus we can replace a large number of variables by a smaller set of instruments without too much loss of information [5].

4 DATA AND SYMBOLS

Usually, it is desirable to test econometric hypotheses using data observed at the greatest possible frequency, not only because it is unclear what the effects of aggregation in time have on a model but also for the simple reason that we generally gain more observations on our variables at a relatively smaller risk of a fundamental change occurring in the underlying structure (and also as it turns out, it is easier to get a large block of homogenous data). However, as this study revealed, there are other factors involved which force a trade-off between the desirable characteristics of more data and statistically significant results. For one thing, it is clear that the factors which influence week to week variability in demand may be more diverse and less related to economic considerations than the factors (such as price and age distribution) which appear to determine the longer period changes.

If we have variation from week to week then we must try to explain it (for the usual reason that large, biased sampling variances lead to invalid testing and inefficient prediction), even though errors correlated weekly appear to play no direct part in determining the true long-term parameters.[2] Thus the only benefit gained from moving from quarterly to weekly data may be a greater confidence in our explanations of future, short-term variations in demand.

Models were run using both weekly and quarterly data. A description of the variables used is provided below.

C/HD: The dependent variable is apparent consumption (ex-factory sales) of wholemilk per head of population in the Sydney metropolitan milk distributing district for the period 2nd April, 1959, to 26th October, 1972, in the case of weekly data, and for the period June, 1959, to September, 1972, in the case of quarterly data. The geographical area involved roughly corresponds to the Sydney Statistical Division defined by the Australian Bureau of Statistics. Sales data are drawn from the Dairy Industry Authority of N.S.W. weekly figures (unpublished); and population data (interpolated) is from [4]. These data represent over 80 per cent of the N.S.W. fresh milk market.

STR: A dummy variable reflecting the impact of strikes by various unions handling milk, and floods which impede milk deliveries. As a proxy for these effects the number of days in which supplies were affected is used as the variable[3].

AWE: The "Average Weekly Earnings per employed male unit" data published quarterly by the A.B.S. (Interpolated for the weekly model).

RAWE: Real incomes, being AWE deflated by the Consumer Price Index for N.S.W.

ADV: The amount spent annually by the Milk Publicity Council on advertisement and promotion of milk (interpolated for weekly and quarterly figures).

MPR: The "money" price of milk, being an estimate of the average cost of a gallon of milk.

RPR: The "real" price of milk; obtained by deflating MPR by the food and beverage component of the Consumer Price Index for N.S.W.

SUD, AUD, WID: Seasonal dummies representing the amount of variation in consumption that occurs in the summer, autumn, and winter seasons respectively, relative to the spring season which is used as a base.

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[2] We can, of course, get a purely mechanical estimate of a weekly model by the fitting of autoregressive-moving-averages but although such estimates will be best, linear, unbiased they will not yield any understanding of the economic processes involved.

[3] The variable was significant in the weekly model only, and even then does not seem to capture all the variation caused by these factors, since very high errors were observed. A better proxy might be some estimate of the quantity not delivered.

AGD (0–5)
AGD (6–14)
AGD (15–20)
AGD (21–64)
AGD (65+)

} The percentage of the population in various age groups; derived from A.B.S. data for the age distribution of the population of N.S.W.

AGDPC (   ): The principal components associated with the age distribution group of variables.

PRM: Monthly production statistics collected by the A.B.S. for processed milk products [4]. This is inserted as a proxy for the effect of substitutes on the demand for milk. Other proxies tried, but yielding insignificant regression coefficients, were monthly production figures for beer, aerated waters and carbonated drinks, cordials and cordial concentrate.

PBF: Monthly production statistics for prepared breakfast foods. This is inserted as a proxy for the effect of the consumption of complementary products on the consumption of milk. Similar data for cocoa powder and drinking chocolate were also tested but yielded insignificant regression coefficients.

SUBSPC 1: The first principal component was tested as an alternative to the inclusion of individual substitute and complement proxy variables.

T: A time trend was included among the independent variables as a check for the non-inclusion of any other long-term factors for which data was not available.

AV (   ): Almon variables associated with the lagged variables of either real or money price. Lag distributions on income variables were individually and collectively insignificantly different from zero.

5 EMPIRICAL RESULTS

(i) *Weekly Model* 702 Observations (April, 1959–October, 1972).

Two models were estimated, both with allowance for autoregressive disturbances. The treatments for autocorrelation was performed by the Australian National University's packaged programme "AUTO" which utilizes the approach outlined by Pagan [17]. Briefly, this is an extension of the Cochran-Orcutt method to any order of autoregression and moving average using the Gauss-Newton non-linear algorithm for solution of the resultant likelihood. It follows that transformations of the estimated functions to take account of autocorrelation is required for best, linear, unbiased prediction. The method has the advantage that standard errors are provided for the estimated autocorrelation parameters, and the autocorrelation function is estimated.

One of the models estimated was the normal, additive linear form in all variables (including U the classical error term):

$$C/HD = a + b_1\ PR + b_2\ AWE + b_3\ ADV + b_4\ T + b_5\ SUD + b_6\ AUD + b_7\ WID + b_8\ STR + U.$$

The other model estimated was a modified Cobb-Douglas model where seasonal and strike dummies entered the equation linearly to avoid singularities:

$$C/HD = a\,(PR^{b_1} \cdot AWE^{b_2} \cdot ADV^{b_3})\, e^{b_4} \cdot T + b_5\, SUD + b_6\, AUD + b_7\, WID + b_8\, STR + U.$$

The results below are the preferred results for the above specifications; chosen on the basis of the maximum number of significant coefficients (excepting seasonal dummies) at the 5 per cent level.

Results: Linear Model

(t statistics in brackets)

$$\begin{array}{llll}
C/HD = 0{\cdot}88 & -\ 0{\cdot}02\ MPR & +\ 1{\cdot}61\ RPR & +\ 0{\cdot}02\ AWE \\
\quad (10{\cdot}31) & (-\ 2{\cdot}20) & (1{\cdot}94) & (2{\cdot}62) \\
-\ 2{\cdot}56\ RAWE & -\ 0{\cdot}04\ T & +\ 0{\cdot}001\ SUD & +\ 0{\cdot}001\ AUD \\
(-\ 2{\cdot}91) & (2{\cdot}10) & (0{\cdot}31) & (0{\cdot}22) \\
-\ 0{\cdot}004\ WID & -\ 0{\cdot}02\ STR & & \\
(-\ 0{\cdot}75) & (-\ 8{\cdot}52) & &
\end{array}$$

The above equation was estimated under the assumption of first order autoregression: $U_t = -\ 0{\cdot}47\ U_{t-1} + E_t$
$$\underset{(-\ 9{\cdot}71)}{}$$

$R^2 = 0{\cdot}51 \qquad DW = 1{\cdot}99$

Both money price and real price and money average weekly earnings and real average weekly earnings have significant coefficients. The signs of the RPR and RAWE variables do not agree with my *a priori* hypothesis. Thus the results are rather inconclusive. It may be that week-to-week consumer responses are somewhat different to the longer term ones uncovered by previous economic analyses, or it may be that the equation is misspecified. The results of the Cobb-Douglas model may have been able to resolve this question. However, convergence problems with the non-linear estimation algorithm prevented the inclusion of several possible significant variables.

Results: Cobb-Douglas

$$C/HD = \underset{(59{\cdot}6)}{0{\cdot}46} \left[\underset{(-\ 11{\cdot}0)}{RAWE^{-\ 0{\cdot}21}} \cdot \underset{(2{\cdot}3)}{RPR^{-\ 0{\cdot}21}} \right]$$

Estimated under the assumption of first order autoregression:

$$U_t = \underset{(-\ 13{\cdot}1)}{-\ 0{\cdot}44}\ U_{t-1} + E_t$$

$R^2 = 0{\cdot}45 \qquad DW = 2{\cdot}01$

The Cobb-Douglas model results in coefficients which are very significant but this significance may decrease as more variables are added. Nevertheless, the R^2 value is almost as high as for the linear model and this indicates that the Cobb-Douglas might be the superior specification. An examination of residuals from regression showed that both of these models gave very poor explanation of the dependent variable during its seasonal peaks and dips (Christmas holidays and school holidays) and during periods when distribution was affected by strikes. Both models gave values which over-estimated consumption by up to 50 per cent during the two weeks after Christmas when milk consumption usually slumps. At other times both models gave excellent estimates with less than 5 per cent error.

The estimated autocorrelation function showed that most of the autocorrelation was removed by allowing for first-order, autoregressive disturbances, except for 52nd order autocorrelation. This is not surprising in view of the above discussion about poor prediction of the seasonal peaks and suggest that improvement could be made by improving the dummy variable representing the effect of strikes and by including dummy variables for holiday periods. However, it would be even more desirable to include at least 52 seasonal dummies in the equation initially and reject those which are insignificant.

It should be noted that much of the autocorrelation in the model was probably manufactured by interpolating variables from quarterly data.

As a rough test for equation stability, all equations were estimated using all or half the observations with no significant change in the estimated coefficients.

(ii) *Quarterly Model* 54 Observations (April, 1959–October, 1972).

It was possible to include more variables in the regression analysis of the Quarterly model and as a result it became desirable to replace groups of collinear variables by principal components (*see* section 3). The principal component analysis of the substitutes and complements group of variables is shown in table 2 and the principal component analysis of the age distribution variables is shown in table 3.

Selected regression results are shown in table 4 and the lag distributions associated with the Almon variables for each equation are shown in table 5.

TABLE 2

First Principal Component—Substitutes/Complements

Variables	Weight
Beer	0·0011
Processed milk	0·0015
Aerated waters and carbonated drinks	0·9914
Cordial	0·1008
Cordial concentrate	0·0032
Prepared breakfast food	0·0028
Drinking chocolate	0·0832

Ratio of maximum to minimum eigen value = 14882700.

The first principal component of this group of variables explains 98·7 per cent of the total variation.

TABLE 3

Principal Components—Age Distribution

Age group	Weights		
	First component	Second component	Third component
0–5	0·8019	0·1969	− 0·0331
6–14	− 0·1404	0·5047	0·8487
15–20	− 0·3073	− 0·5973	0·2474
21–64	− 0·4741	0·5882	− 0·4663
65 + ...	0·1342	0·0616	0·0050

First principal component accounts for 44·5 per cent of the variation.

Second principal component accounts for 30·77 per cent of the variation.

Third principal component accounts for 21·23 per cent of the variation.

The lag distributions of milk price variables are reported as the sum of the corresponding Almon variables in table 4. The lag distributions are shown in table 5. Coefficients for ADV, the proxy variable for the effect of advertising, and for AUD, the third seasonal dummy, are not reported as they were invariably statistically insignificant and the regression equations in which they were tested were not otherwise of any interest. Other coefficients which were always insignificant were AWE, RAWE, STR, PRM, PBF, SUBSPC1, AGDPC2 and AGDPC3. The coefficients for MPR, TIME and AGD ( ) were sometimes significant at the five per cent level. The coefficients for AGDPC1, RPR or ΣA.V. (corresponding to a lagged distribution of RPR), and the constant term were almost always significant at the 5 per cent level.

Consider the regression equations in table 4. Equations 1 and 2 are obviously misspecified and equations 3, 4 and 5 contain coefficients which are insignificant at the 5 per cent level. Thus number 6 is the preferred equation since all estimated coefficients are highly significant and any additional variables add very little, individually, to explanation of the total variation (as measured by the coefficient of determination).

The lag distributions for the real price variable shown in table 5 are quite uniform despite variations in the degree of the approximating polynomial, the length of the lag distribution, and the application of zero restrictions to the tails of the lag distributions. It should be noted that individual t statistics reported for lagged variables are not necessarily accurate since in their estimation by Almon variables they are interdependent. The t statistic for the sum of the variables is a more reliable indicator of their overall significance.

TABLE 4

Regression Results—Quarterly Model

Equation No.	CONST	MPR	AWE	AGD (0–5)	AGD (6–14)	AGD (15–20)	AGD (21–64)	AGD (65 +)	SUD	WID	TIME	ΣA.V.*	STR	PRM	PBF	R^2	DW
1 ..	6·29	3·41	..	31·51	..	22·62	..	− 4·57	0·07	− 0·004	− 2·39	− 4·32	..	..	..	0·83	2·76
	(1·18)	(1·74)	..	(1·22)	..	(2·58)	..	(− 1·30)	(1·75)	(− 0·12)	(− 2·12)	(− 2·01)	..	..	..		
2 ..	11·55	..	− 0·0007	0·03	− 0·04	..	− 0·06	..	..	..	0·01	0·02	− 0·008	0·00002	0·00003	0·69	1·67
	(4·04)	..	(− 0·31)	(0·35)	(− 0·89)	..	(− 0·90)	..	..	..	(0·29)	(− 1·56)	(− 0·64)	(0·02)	(0·07)		
	CONST	MPR	AWE	AGDPC 1	AGDPC 2	AGDPC 3					TIME	ΣA.V.		SUBSPC 1			
3 ..	15·11	0·03	− 0·03	0·29	0·04	0·01					0·002	(− 6·64)		0·01		0·76	2·06
	(5·77)	(1·07)	(− 1·17)	(2·99)	(0·77)	(0·24)					(0·49)	(2·71)		(0·19)			
4 ..	14·40	− 0·006	..	0·20	..	..					..	− 3·34		..		0·73	2·02
	(8·54)	(− 1·46)	..	(3·19)	..	..					..	(− 2·95)		..			
5 ..	14·24	− 0·004	− 0·001	0·19	..	..					..	− 16·10		..		0·73	2·05
	(8·32)	(− 0·72)	(− 0·65)	(3·09)	..	..					..	(− 1·54)		..			
6 ..	16·08	..	..	0·28	..	..					..	− 3·95		..		0·72	1·95
	(12·94)	..	..	(9·78)	..	..					..	(− 3·71)		..			

t—statistics in brackets.

* ΣA.V.—sum of lag coefficients in the Almon variables.

TABLE 5

Lag Distributions for Almon Variables

Equation No.	Lag 0	1	2	3	4	5	6
1	– 4·21 (– 3·50)	– 1·06 (– 2·02)	– 0·007 (– 0·01)	– 0·13 (– 0·43)	– 0·49 (– 1·07)	– 0·17 (– 0·37)	1·75 (2·02)
	Associated variable: Real price, Degree of approximating Polynomial 3, No zero restrictions.						
2	– 0·02 (– 1·99)	– 0·002 (– 0·48)	0·004 (0·72)	0·004 (0·82)	– 0·005 (– 0·51)	.. ..	.. ..
	Associated variable: Money price, Degree of approximating Polynomial 2, No zero restrictions.						
3	– 4·79 (– 2·23)	– 1·34 (– 2·32)	0·40 (0·65)	0·40 (0·78)	– 1·32 (– 1·53)	.. ..	.. ..
	Associated variable: Real price, Degree of approximating Polynomial 2, No zero restrictions.						
4	– 1·62 (– 2·82)	– 0·99 (– 3·25)	– 0·52 (– 1·81)	– 0·19 (– 0·63)	– 0·02 (– 0·09)	.. ..	.. ..
	Associated variable: Real price, Degree of approximating Polynomial 2, Zero restriction at 5th lag.						
5	– 3·88 (– 1·87)	– 3·55 (– 1·71)	– 3·24 (– 1·53)	– 2·89 (– 1·37)	– 2·54 (– 1·20)	.. ..	.. ..
	Associated variable: Real price, Degree of approximating Polynomial 1, Zero restriction at 5th lag.						
6	– 2·02 (– 3·91)	– 1·19 (– 4·33)	– 0·58 (– 2·04)	– 0·18 (– 0·59)	0·02 (0·07)	.. ..	.. ..
	Associated variable: Real price, Degree of approximating Polynomial 2, Zero restriction at 5th lag.						

t—statistics in brackets.

6 CONCLUSIONS

The results indicate that long-run milk consumption per head is determined by a relatively small set of factors. These are a lag distribution of real prices and a complicated function of the age distribution of the population.

Table 2 shows that the linear combination of the age group variables that constitutes the first principal component is constructed in such a way that the 0–5 and 65+ age groups enter positively and the 6–64 age groups enter negatively. Combined with the positive coefficients in the regression equations 4, 5 and 6 this result leads to the conclusion that a rise in the proportion of the population in the 6–64 age groups will lead to a fall in consumption, and a rise in the proportion in the 0–5 and 65+ age groups will cause a rise in consumption. This is a fortuitous result which is not usually supplied by the application of principal component analysis.

The lag distribution for the real price variable indicates that increases in the real price of milk will cause a relatively large decrease in consumption of milk per head in the same quarter. Later adjustments in response to the real price increase cause further, smaller decreases in consumption up to four quarters later. There may be a relatively small increase in consumption (indicated by equation 6) in the fourth quarter after the price increase. However, the nett response to an increase in real price is a decrease in consumption. Conversely, a decrease in real price could be expected to increase consumption. It should be noted that the retail price for milk has never been decreased by the Authority, however, the real price has declined on occasion due to relatively faster increases in the consumer price index.

It may also be useful to get an estimate of the point, price elasticities of demand over the range of values for the demand (consumption/price) schedule supplied by the data.

The formula used is $e_d^P = -\frac{\delta q}{\delta p}\frac{P}{q}$, where e_d^P represents the point price elasticity of demand, p the real price and q the quantity consumed per head. To satisfy the *ceteris paribus* requirement the age distribution variable for the preferred equation was set at $-22{\cdot}04$, its value in October, 1972. The differential of the resulting function was evaluated at real prices per gallon of 80 cents and 92 cents, these being the lowest and highest values obtained in the sample data. Thus the estimated price elasticities are $-0{\cdot}47$ and $-0{\cdot}58$ respectively.

This price elasticity implies that consumers become more responsive to changes in the real price of milk as the absolute value of that price rises, all other things remaining equal. These, of course, are long-run elasticities whose effects work themselves out over periods of one year. Thus they do not necessarily disagree with previous estimates (table 1) which indicate a lower price elasticity. Indeed, by estimating the point elasticity for the zero lag (equation 6, table 5) we arrive at figures of $-0{\cdot}19$ and $-0{\cdot}23$ corresponding to real prices of 80 and 92 cents per gallon respectively.

The results do not support any hypotheses that income, advertising, substitutes or complements have any effect whatsoever upon the consumption of milk. However, the data used in this study are very poor proxies for the effects that tastes and habits have on consumption and this should be borne in mind. If these effects are significant in determining consumption there is the unfortunate possibility of some specification error entering the estimation procedure. Nevertheless, it seems natural and I believe, optimal in the absence of better data, to treat the above results as a valid representation of consumer demand for milk. Further results will hopefully be mere refinements on the established explanation of consumer behaviour.

The major findings of this analysis, that milk consumption per head is determined by the real price of milk and by the age distribution of the population, agree very well with previous results. The results would appear to be more useful than previous results in that explicit recognition is given to the effect of age distribution on aggregate consumption. Thus explicit numerical predictions can soon be made to aid in policy decisions and in planning for future milk marketing.

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