THE DEMAND FOR MILK:
AN ECONOMETRIC ANALYSIS OF THE NEW ZEALAND MARKET

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RESEARCH REPORT NO. 147
January 1984

Agricultural Economics Research Unit
Lincoln College
Canterbury
New Zealand

ISSN 0069 3790
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The New Zealand Milk Board is responsible for managing the supply quota scheme for town milk farms, is involved in fixing allowances for various sectors of the milk processing and distribution chain, and is charged with making recommendations to government on the consumer price for milk. Hence, the monitoring of consumer demand, identifying factors affecting demand, and the estimation of future demand patterns are all of vital interest to the Board's activities. This interest has heightened with declining sales for nearly a decade and the adjustment problems within the industry that are associated with such a decline.

The principal objective of this report is to identify factors determining the demand for milk in New Zealand. This is achieved by use of an econometric model.

The report was written by Dr R.J. Brodie (Senior Lecturer in the Department of Agricultural Economics and Marketing at the College), Mr R.G. Moffitt (Research Economist in the Agricultural Economics Research Unit) and Mrs J. Gough (Temporary Research Economist in the Department). Financial support for the project was forthcoming from the New Zealand Milk Board, the Department of Agricultural Economics and Marketing and the A.E.R.U.
SUMMARY

This report presents the results of a preliminary econometric analysis of the factors affecting town milk consumption in New Zealand. The study objectives are:

(1) to review overseas studies which have examined the demand for fluid milk;

(2) to specify and estimate quarterly and annual econometric models in order to quantify the factors which determine demand; and

(3) to investigate the models' suitability for short-term and medium-term forecasting and policy analysis.

The study demonstrates that econometric analysis provides an effective tool for quantifying the factors which determine the per capita consumption of milk. The estimated models show consumption is largely determined by four factors. These are:

(1) the previous period's consumption level,

(2) the real price of milk,

(3) the proportion of young people in the population, and

(4) seasonal factors.

The New Zealand market is very price inelastic or unresponsive to price changes and is even more unresponsive than the Australian market.

Other factors such as disposable income and advertising do not appear to have an important influence on milk consumption but further investigation is necessary to determine their exact effect.

The estimated models appear to be highly suitable for accurate short- and medium-term forecasts.

The authors are confident that an extension of this analysis will lead to the development of a valuable tool to be used by the industry to plan and co-ordinate its marketing programme over the next decade.
CHAPTER 1

BACKGROUND AND STUDY OBJECTIVES

1.1 Background

New Zealand's domestic consumption of fluid milk peaked in 1975 when over 422 million litres of pasteurised town milk were sold in New Zealand. Since then both total and per capita consumption have declined. This has occurred despite the efforts made by the New Zealand Milk Board to stimulate demand. While a number of factors such as consumer resistance to higher prices, a changing age structure in the population, falling real incomes and changing consumer tastes may have precipitated this decline, the nature of these effects is not known.

1.2 Study Objectives

The main objective of this study is to demonstrate the way in which econometric analysis can be used for three different specific purposes:

(1) historical analysis - quantifying the factors which determine demand for milk and evaluating the effects of price increases, the effectiveness of advertising, and other marketing activity;

(2) forecasting seasonal and annual sales; and

(3) policy analysis - exploring the consequences of future policy alternatives. For example, the econometric model can be used to indicate how much per capita consumption falls for different levels of price increases.

1.3 Outline of Report

Chapter 2 reviews previous studies in order to identify the factors affecting the demand for milk, Chapter 3 outlines the methodology and Chapter 4 presents the results. First the results for the quarterly (short-term) model are presented, followed by the results for the annual (medium-term) model. Finally Chapter 5 draws conclusions about the usefulness of the models, whether the results were consistent with overseas studies and makes recommendations about further research.
CHAPTER 2

FACTORS AFFECTING MILK CONSUMPTION

On the basis of marketing theory and evidence from overseas studies, a number of factors or variables need to be considered in demand models for milk. These include the price of milk, disposable income, age distribution of the population, the price of milk substitutes, consumer attitudes towards such factors as the health and "goodness" of milk versus milk substitutes, and finally the influence of advertising and other forms of marketing activity for milk and its substitutes. The remainder of this chapter reviews the evidence from previous studies about the relative importance of these factors.

2.1 Price

Overseas studies indicate that the price for milk is very inelastic in the short term with price elasticities generally less than -0.2. Perhaps the most relevant assessment is an Australian study by Nelson (1977) which used a quarterly time series model to examine the demand for milk in the states of Victoria and New South Wales. The price elasticity for per capita consumption of milk was estimated to be -0.10 in Victoria and -0.15 in New South Wales.

Most of the overseas studies adjusted the price of milk for inflation instead of using the nominal price. Because of the high rate of New Zealand inflation during the study period this study examines changes in both the nominal and real (inflation adjusted) price.

The use of real values assumes the absence of money illusion in consumer behaviour. Money illusion exists when high inflation causes consumers to lose sight of the true purchasing power of money. They believe that values are measured in dollars rather than by the amount of goods and services that those dollars will buy. A price rise in milk is usually followed by a large initial drop in consumption. It may take consumers some time to adjust their purchasing decisions. Consumers eventually readjust consumption to a level higher than that prevailing immediately following the price rise but marginally lower than that observed before the price increase. The study by Nelson (1977) failed to reveal any effect of money illusion in the Victoria or New South Wales markets. If there had been money illusion present the readjustment had taken place within the three month observation interval.

---

1 The elasticity of demand is defined as the percentage change in the quantity demanded associated with a percentage change in a causal variable, with the ceteris paribus assumption of all other factors remaining constant. The elasticity is called inelastic when it is less than one and elastic when it is greater than one.

3.
2.2 Income

Real disposable income is another factor which affects the level of consumption of food items. However, overseas studies indicate that milk is regarded as a necessity by consumers and so is not affected by income changes. For example two U.S.A. studies by George and King (1971) and Boehm (1976) estimated the income elasticities to be 0.2 and 0.1 while the Canadian study by Lu and Marshall (1973), the UK study by Strak and Gill (1983), and the Australian studies by Nelson (1977) and Street (1974) found changes in income to be unrelated to milk demand.

2.3 Age

Overseas evidence indicates the age composition of the population to have a very strong influence on the per capita consumption of milk with high levels of consumption by children. A 1965 consumer survey by the United States Department of Agriculture (1970) found that children under 10 years of age consumed three times as much milk as people over 35 years. A decline in milk consumption began at about 12 years for females and 17 years for males. This decline in milk consumption continued until about 65 years of age when it slowly started to rise again. A Canadian consumer research study reported by Lu and Marshall (1973) found that children consumed more milk than teenagers did and teenagers' milk consumption was greater than that of adults.

The econometric evidence from the U.S.A. (e.g. Boehm (1976) and Schrimper (1975)) and Australia (e.g. Street (1974) and Nelson (1977)) also supports the hypothesis that the decline in the proportion of children in the population is an important factor in the decline in milk consumption.

2.4 Milk Substitutes

Nelson (1977) emphasises that little is known about the exact interrelationships between milk and other beverages. The complexity in identifying the influence of substitutes is highlighted by the large range of different consumer uses for milk. For example a recent consumer survey commissioned by the New Zealand Milk Board (1983) indicates that 29 percent of milk is used on breakfast cereals or porridge; 29 percent as a cold milk drink; 14 percent as a hot milk drink; 9 percent with tea and coffee; 12 percent for cooking and baking and 7 percent on desserts.

Because of the wide variety of uses it can be concluded that in the short term, aggregate consumption of milk is not likely to be affected markedly by competition from substitutes in any one of these milk categories.

2.5 Advertising and Other Marketing Activity

Only three studies were found which took into account the effects of advertising and no studies were found which examined the effects of other forms of marketing activity such as public relations, product and packaging innovation and point of sale promotion. The two U.S.A. studies by Chen et al. (1972) and Thompson and Eiler (1975) which measured the effects of advertising emphasise the dynamic effects. The studies show
that while the current effects of advertising may not be large there are important carry-over effects which may last up to a year. Similar conclusions were drawn by Strak and Gill (1983) in the study of the U.K. market. The study indicates that short-term (monthly) advertising elasticities to be less than 0.01 and the long-run elasticity computed from the cumulative values to be 0.03.

2.6 Consumer Attitudes and Behaviour

No overseas studies were found which explicitly accounted for the effect of changes in consumer attitudes and behaviour. In some studies a time trend variable was included to reflect a steady change in attitudes and behaviour over the study period.
CHAPTER 3

METHODOLOGY

3.1 Model Specification

Two basic models were specified; a quarterly model is used for short-term forecasting and policy analysis and an annual model is used for medium- and long-term forecasting and policy analysis. The dependent variable in both cases is the per capita consumption of milk, and the independent variables are the price of milk, measures of disposable income, measures of the age structure of the population, and amount spent on advertising. A lagged consumption variable is included to allow for the effects of past consumption on present consumption, and the quarterly model contained dummy variables to reflect seasonality. Both linear and log-linear models were specified, and an optional trend variable was included in the annual model.

The initial specification of the quarterly linear model is

\[
\text{CONS} = b_0 + b_1 \text{CONS}(-1) + b_2 \text{PRICER} + b_3 \text{WAGER} + b_4 \text{AGE}^{0-14} + b_5 \text{ADVR} + b_6 D_1 + b_7 D_2 + b_8 D_3 + U
\]

where

- \text{CONS} = pasteurized milk consumption per head per quarter
- \text{CONS}(-1) = previous period's consumption per head
- \text{PRICER} = price of milk per litre deflated by the CPI for food
- \text{WAGER} = real wage rate
- \text{AGE}^{0-14} = percentage of the population in the 0 to 14 year old age group
- \text{ADVR} = advertising expenditure (adjusted for inflation)
- \text{D}_1, \text{D}_2, \text{D}_3 = Dummy seasonal variables relative to the first quarter (January-March)
- U = Random error term

3.2 Model Estimation, Evaluation and Testing

The models were estimated using ordinary least squares and then evaluated for specification errors and face validity. This included testing for autocorrelation and examining the parameter estimates to see if they are consistent with a priori expectations. For example the price elasticity is expected to be negative and small in value.

To assess its forecasting accuracy, the model's observations outside the data set were compared with the values which were predicted by the estimated models.

The data used to estimate the models are presented in Appendix B.

---

2 See Appendix A for the justification of including a lagged consumption variable.
CHAPTER 4

RESULTS

4.1 Quarterly Models

This section describes the results for the quarterly models. These models aim to quantify the factors which affect consumption of milk in the short term.

4.1.1 Initial Analysis of Data

The graphical analysis of per capita consumption (see Figure 1) indicates an initial increase in the consumption of milk up to 1975 and then an overall decline. Consumption is also characterised by marked seasonal differences between the quarters with consumption being lower in the summer period.

Price

There was little change in the price of domestic town milk until early 1976, but since that date there has been at least one price increase each year. On February 1, 1976 the price for a 600 ml bottle of milk doubled from 4 cents to 8 cents. In March 1983 the price was 30 cents per 600 ml (see Table 1).

<table>
<thead>
<tr>
<th></th>
<th>Price per bottle</th>
<th>Price per litre</th>
</tr>
</thead>
<tbody>
<tr>
<td>January 1971</td>
<td>4c/pint</td>
<td>7.0423 cents</td>
</tr>
<tr>
<td>March 1974</td>
<td>4c/600 ml</td>
<td>6.6667</td>
</tr>
<tr>
<td>February 1976</td>
<td>8c/600 ml</td>
<td>13.3333</td>
</tr>
<tr>
<td>February 1977</td>
<td>9c/600 ml</td>
<td>15.0000</td>
</tr>
<tr>
<td>May 1978</td>
<td>10c/600 ml</td>
<td>16.6667</td>
</tr>
<tr>
<td>April 1979</td>
<td>15c/600 ml</td>
<td>25.0000</td>
</tr>
<tr>
<td>February 1980</td>
<td>18c/600 ml</td>
<td>30.0000</td>
</tr>
<tr>
<td>November 1980</td>
<td>21c/600 ml</td>
<td>35.0000</td>
</tr>
<tr>
<td>August 1981</td>
<td>25c/600 ml</td>
<td>41.6667</td>
</tr>
<tr>
<td>June 1982</td>
<td>30c/600 ml</td>
<td>50.0000</td>
</tr>
</tbody>
</table>

Figure 1: QUARTERLY MILK CONSUMPTION PER HEAD

Figure 2: MILK PRICE DEFLATED BY C.P.I. (FOOD)
The money price of town milk was deflated to the real price using the food component of the Consumers Price Index. Figure 2 highlights the gradual decline in real price which occurred after each milk price increase.

Income

While there was a steady increase in the nominal weekly wage between 1972 and 1983 there was little variation in the real wage rate (see Appendix B).

Age Structure of the Population

There was a steady decline in the proportion of the population under 14 years from 31 percent to 26 percent over the study period from January 1972 to March 1983 (see Appendix B).

Advertising

Prior to November 1977 the Milk Publicity Council of New Zealand undertook very little media advertising and promotion. After this period the annual expenditure, by the restructured council (called the New Zealand Milk Promotion Council) was increased considerably. A substantial amount of this expenditure was on TV advertising (see Table 2).

<table>
<thead>
<tr>
<th>Year Ending March</th>
<th>$,000 (nominal)</th>
<th>$,000 (real)(^a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1978</td>
<td>223.0</td>
<td>413.3</td>
</tr>
<tr>
<td>1979</td>
<td>426.7</td>
<td>673.9</td>
</tr>
<tr>
<td>1980</td>
<td>353.6</td>
<td>463.6</td>
</tr>
<tr>
<td>1981</td>
<td>165.5</td>
<td>185.9</td>
</tr>
<tr>
<td>1982</td>
<td>473.8</td>
<td>473.8</td>
</tr>
<tr>
<td>1983 (estimated)</td>
<td>541.1</td>
<td></td>
</tr>
</tbody>
</table>

\(^a\) converted to 1982 dollars
4.1.2 Estimation Results

The estimated demand function for the final model's specification is:

\[
\text{CONS} = 0.804 + 0.628 \text{CONS}(-1) - 0.066 \text{PRICER} \\
(4.01) (10.15) (-5.81)
\]

\[
+ 0.188 \text{AGE}014 + 0.013 D_1 + 0.056 D_2 + 0.039 D_3 \\
(3.25) (3.23) (12.66) (10.36)
\]

\[
R^2 = 0.987 \quad F (6, 37) = 527.2 \quad \text{D.W.} = 2.09
\]

where the t statistics are given in brackets underneath the estimated coefficients; \(R^2\) is the coefficient of variation adjusted for the number of independent variables and D.W. is the Durbin Watson Statistic. All the variables are in log form and are defined as:

- \(\text{CONS}\) = pasteurized milk consumption per head
- \(\text{CONS}(-1)\) = the previous period's pasteurized milk consumption per head
- \(\text{PRICER}\) = the price of milk per litre deflated by the consumer price index for food
- \(\text{AGE}014\) = the proportion of the population between 0 and 14 years
- \(D_1, D_2, D_3\) = Dummy seasonal variables relative to the first quarter (January-March).

Under this specification all the parameter estimates have the expected signs and are statistically significant at the 99 percent confidence level. The Durbin Watson statistic indicates the model to be free from specification error and the high \(R^2\) and F statistic values indicate that the model explains variation in per capita consumption of milk extremely well. The "goodness of fit" of the model is highlighted in Figure 3 where actual and predicted values are plotted.

The initial model specifications also included a real wage rate index and an advertising dummy variable. However these variables were dropped from the final specification because they were not statistically significant. The estimation results for these models are included as Table 3. Specifications which included lagged real price and the undeflated money price of milk as variables were also estimated to test for money illusion effect. The lack of statistically significant results is consistent with Nelson's (1977) Australian results and indicates, if there is money illusion present, the adjustment takes place within three months.

---

3 The log-linear model is given because the elasticities can be read directly. The estimation results for the linear model are given in Table 3.
Figure 3: QUARTERLY ACTUAL VS. PREDICTED VALUES
## TABLE 3

Estimation Results for Quarterly Models

<table>
<thead>
<tr>
<th>Variable</th>
<th>Linear Models</th>
<th>Log-Linear Models</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>10.134 (5.10)**</td>
<td>10.848 (4.16)**</td>
</tr>
<tr>
<td>CONS(-1)</td>
<td>0.577 (10.21)**</td>
<td>0.578 (9.87)**</td>
</tr>
<tr>
<td>PRICER</td>
<td>-0.159 (-7.08)**</td>
<td>-0.160 (-6.91)**</td>
</tr>
<tr>
<td>AGEØ14</td>
<td>0.172 (3.16)**</td>
<td>0.169 (2.61)**</td>
</tr>
<tr>
<td>WAGER</td>
<td>-</td>
<td>-0.001 (-0.47)</td>
</tr>
<tr>
<td>D1</td>
<td>0.372 (3.26)**</td>
<td>0.376 (3.17)**</td>
</tr>
<tr>
<td>D2</td>
<td>1.648 (13.37)**</td>
<td>1.641 (12.85)**</td>
</tr>
<tr>
<td>D3</td>
<td>1.207 (11.72)**</td>
<td>1.203 (11.34)**</td>
</tr>
<tr>
<td>ADVR</td>
<td>-</td>
<td>-0.003 (-0.015)</td>
</tr>
<tr>
<td>$\bar{R}^2$</td>
<td>0.989</td>
<td>0.989</td>
</tr>
</tbody>
</table>

$F(6,37)=662.2$ $F(8,35)=473.2$ $F(6,37)=527.2$ $F(8,35)=384.3$

DW | 2.25 | 2.21 | 2.09 | 2.07

Number of Observations | 44 | 44 | 44 | 44

Note: The values in brackets under the parameter estimates are the t statistics. ** indicates that the estimate is statistically significant at the 99% confidence level and * the 95% confidence level.
4.1.3 Comments on the Factors Which Determine Per Capita Consumption of Milk

The estimated models show that quarterly per capita consumption of town milk is largely determined by four factors. They are:

(1) the previous period’s consumption level
(2) the real price of milk (not the nominal price)
(3) the proportion of young people in the population
(4) seasonal factors.

The high t-values for the parameter estimates for all of these variables mean a high level of confidence can be placed in the accuracy of the estimates. Because the model is specified in a log-linear form the parameter estimates for the CONS(-1), PRICER and AGE014 variables can be interpreted directly as elasticities.

The price elasticity of -0.066 indicates that the market is very price inelastic or unresponsive to price changes. For example a 10% increase in real price for milk would only lead to less than a 1% decrease in consumption. The value of -0.066 is less than Nelson’s (1977) estimates of -0.10 and -0.15 for the Victoria and New South Wales markets indicating that the New Zealand domestic market is even less responsive to price than the Australian market.

The age structure elasticity of 0.188 indicates the age structure of the population has a very important influence on per capita consumption. For example a decrease from 25 percent to 20 percent in the proportion of population in the 0 to 14 age group would result in nearly a 4 percent decrease in per capita consumption of milk.

The parameter of 0.628 for the lagged consumption variable can be interpreted as a habit or inertia index. It indicates that current consumption is strongly influenced by previous consumption patterns and any stimulation of current consumption will be dampened by this inertia factor.

The parameter estimates of 0.013, 0.056 and 0.039 for D1, D2 and D3 provide indices which indicate the percentage change in milk consumption which is caused by seasonal effects for the April, May, June; July, August, September; and the October, November, December quarters. The high t-values indicate that the seasonal consumption pattern is very stable.

The conclusions about the effects of disposable income, advertising and the other factors discussed in Chapter 2 are less conclusive. While this initial investigation clearly shows these factors have not had a strong influence nevertheless it fails to identify exactly what type of influence they have had. Further analysis is needed before any clear conclusions can be drawn.
4.1.4 Forecasting Performance of the Quarterly Models

A rigorous test of the forecasting ability of the models consists of a comparison of actual values with predicted values for observations outside the data set used to estimate the models' parameters. To examine the ex-post validity of the models the final specifications of the linear and log-linear models were re-estimated using data from 1972 to 1980 and then estimated models were used to forecast the nine quarters from 1981 onwards.

The results of these simulations, given in Table 4, indicate the linear model is preferred to the log-linear model as the log-linear model consistently over-estimates. With the exception of 2 periods the linear model gives forecasts within 1 percent of the actual values.

**TABLE 4**

Ex-Post Forecasts for Quarterly Models

<table>
<thead>
<tr>
<th>Year Quarter</th>
<th>Linear Model</th>
<th>Log-Linear Model</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Actual</td>
<td>Predicted</td>
</tr>
<tr>
<td>1981 1</td>
<td>28.1</td>
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<td>27.6</td>
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<td>26.5</td>
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<td>Theil's U</td>
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<tr>
<td>Root Mean Squared Error</td>
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</table>
4.2 **Annual Models**

This section describes the results for the annual models. These models were developed to quantify the factors which affect consumption of milk in the long run.

4.2.1 **Initial Analysis of Data**

The quarterly model used data from 1972 to 1983. In order to obtain the maximum information possible the data series was extended for the annual model to cover the period 1959–60 to 1982–83. The period used was the August year so to coincide with the Milk Board's planning year. The increase in milk consumption up to 1975 followed by a steady decrease is again shown in Figure 4. Here it can be seen that the decline is twice as rapid as the initial increase.

**Price**

The price of milk between 1959–60 and 1971–72 remained constant at 4c/pint or 7.0423c/litre. Therefore, for the first part of the period whilst consumption is increasing, nominal price is a constant. As for the quarterly model the price of milk is deflated to the real price using the food component of the Consumer Price Index (see Figure 5).

**Income**

The annual model used a wage index variable similar to that included in the quarterly model as an indicator of real disposable income. The index indicates that income was relatively stable in the early 1960s followed by a marked increase between 1969 and 1972 and since then it has remained relatively stable (see Appendix B).

**Age Structure of the Population**

Figure 5 shows a steadily declining proportion of the population under the age of 15 years from 33 percent in 1960 to 26 percent in 1983.

**Advertising**

Advertising was included from 1976/77 onwards. Prior to this the low milk price had led to a continual demand for milk without the need for much advertising. Since then there has been considerable fluctuation in the level of advertising expenditure (see Table 2).

4.2.2 **Estimation Results**

Two versions for final model specification are given; one including the trend variable and one excluding the trend variable. The model has been estimated with two objectives. Firstly, it is required to identify factors determining the demand for milk. In this context inclusion of the trend variable is questionable since there is little theoretical justification for its presence. Secondly, the model is to be used to
Figure 4: ANNUAL MILK CONSUMPTION PER HEAD

180
170
160
150
140
130
120
110

YEARS

Figure 5: REAL PRICE OF MILK: POPN 0-14

Key:

- - - Real Price of Milk
- - Propn of Popn 0-14 Years
predict future levels of demand, and in this case the trend variable does have relevance.

The estimated demand functions for the log-linear models are:

1. \[
\text{CONS} = 1.612 + 0.745 \text{CONS}(-1) - 0.064 \text{PRICER} + 0.133 \text{AGE}14 \]
   \[
   \begin{align*}
   & (4.15) \quad (10.12) \quad (-3.76) \quad (4.48) \\
   \end{align*}
   \]
   \[
   \bar{R}^2 = 0.974, \quad F(3,19) = 275.2, \quad DW = 1.86
   \]
   \[
   \text{CONS} = \text{pasteurized milk consumption per head} \\
   \text{CONS}(-1) = \text{previous period's consumption per head} \\
   \text{PRICER} = \text{price of milk per litre deflated by the CPI for food} \\
   \text{AGE}14 = \text{the proportion of the population aged 0-14 years}
   \]
   All parameter estimates have expected signs, and all are significant at 99% level. The high \(\bar{R}^2\) values suggest a 'good fit' by the model. The Durbin Watson statistic does not indicate first order autocorrelation of the error terms. The "goodness of fit" of this model is highlighted in Figure 6.

2. \[
\text{CONS} = 2.409 + 0.606 \text{CONS}(-1) - 0.067 \text{PRICER} + 0.296 \text{AGE}14 + 0.030 \text{TREND}
\]
   \[
   \begin{align*}
   & (5.80) \quad (7.96) \quad (-4.69) \quad (5.05) \quad (3.06) \\
   \end{align*}
   \]
   \[
   \bar{R}^2 = 0.985, \quad F(4,18) = 299.9, \quad DW = 2.44
   \]
   \[
   \text{TREND is a time trend } (1, 2, \ldots, 25)
   \]
   In this case \(\text{CONS}(-1), \text{PRICER, AGE}14\) and \(\text{TREND}\) parameter estimates are all significant at the 95% level and the Durbin Watson statistic indicates absence of first order autocorrelation.

The price elasticities calculated are similar to those for the quarterly model as are the lagged consumption variable partial adjustment elasticities. The inclusion of the trend variable has most marked effect on the age structure parameter where the elasticity is changed considerably. This means the elasticity for the age structure variable should be interpreted with caution.

Models including wage indices and advertising expenditure were also estimated and the results are given in Table 5. Neither of these variables had a statistically significant effect on consumption.

4.2.3 Forecasting With the Annual Models

One of the interests of the New Zealand Milk Board was use of the models to make annual forecasts for milk consumption over an extended period. In particular predictions were required for the five yearly period 1983-84 to 1987-88 for increases in the real price of milk of
Figure 6: ANNUAL MODEL ACTUAL VS. PREDICTED VALUE

MILK CONSUMPTION IN LITRES (per head)

Key: Actual ————
      Predicted ————-
## Table 5

Estimation Results for Annual Models

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<tr>
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<th></th>
<th></th>
<th></th>
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<tbody>
<tr>
<td>Constant</td>
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<td>6.247</td>
<td>-8.953</td>
<td>1.612</td>
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<td>2.247</td>
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<td>CONS(-1)</td>
<td>0.649</td>
<td>0.556</td>
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<td>PRICER</td>
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<td>-0.061</td>
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<td>AGE@14</td>
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<td>ADVR</td>
<td>-</td>
<td>-</td>
<td>0.000</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>TREND</td>
<td>-</td>
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<td>0.519</td>
<td>0.030</td>
<td>0.028</td>
<td>0.028</td>
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<tr>
<td>$\overline{R}^2$</td>
<td>0.974</td>
<td>0.981</td>
<td>0.975</td>
<td>0.974</td>
<td>0.985</td>
<td>0.904</td>
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<tr>
<td>F</td>
<td>$F(3,19)=240.0$</td>
<td>$F(4,18)=233.8$</td>
<td>$F(6,16)=142.7$</td>
<td>$F(3,19)=275.2$</td>
<td>$F(4,18)=299.9$</td>
<td>$F(6,16)=35.4$</td>
</tr>
<tr>
<td>Number of Observations</td>
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<td>23</td>
<td>23</td>
<td>23</td>
<td>23</td>
<td>23</td>
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</tbody>
</table>

Note: The values in brackets under the parameter estimates are the t statistics; ** indicates the estimate is statistically significant at the 99% confidence level and * the 95% level.
In order to choose the "best" model for forecasting ex-post validity tests similar to the ones for the quarterly models were undertaken. The linear and log-linear models were estimated using data from 1960 to 1978 and the estimated models were used to forecast the five years from 1979 to 1983. The results of these simulations given in Table 6 indicate the log-linear model with the trend variable included is preferred to the other specification as it has the lowest average errors.

**TABLE 6**

Ex-Post Forecasts for the Annual Model

(a) Trend Excluded

<table>
<thead>
<tr>
<th>Year Ending</th>
<th>Linear Model Actual</th>
<th>Predicted</th>
<th>Error</th>
<th>Log-Linear Model Actual</th>
<th>Predicted</th>
<th>Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>1979</td>
<td>122.6</td>
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<td>-2.1%</td>
<td>122.6</td>
<td>120.5</td>
<td>-1.7%</td>
</tr>
<tr>
<td>1980</td>
<td>118.5</td>
<td>117.8</td>
<td>-0.6%</td>
<td>118.5</td>
<td>118.0</td>
<td>-0.4%</td>
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<td>1981</td>
<td>114.5</td>
<td>111.7</td>
<td>-2.4%</td>
<td>114.5</td>
<td>113.0</td>
<td>-1.3%</td>
</tr>
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<td>1982</td>
<td>113.5</td>
<td>107.9</td>
<td>-4.1%</td>
<td>113.5</td>
<td>109.5</td>
<td>-3.6%</td>
</tr>
<tr>
<td>1983</td>
<td>110.7</td>
<td>106.7</td>
<td>-3.6%</td>
<td>110.7</td>
<td>108.3</td>
<td>-2.2%</td>
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</tbody>
</table>

Theil's U 0.015 0.010
Root Mean Squared Error 3.56 2.40

(b) Trend Included

<table>
<thead>
<tr>
<th>Year Ending</th>
<th>Linear Model Actual</th>
<th>Predicted</th>
<th>Error</th>
<th>Log-Linear Model Actual</th>
<th>Predicted</th>
<th>Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>1979</td>
<td>122.6</td>
<td>120.9</td>
<td>-1.3%</td>
<td>122.6</td>
<td>121.8</td>
<td>-0.7%</td>
</tr>
<tr>
<td>1980</td>
<td>118.5</td>
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<td>0.5%</td>
<td>118.5</td>
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<td>1.2%</td>
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<td>1981</td>
<td>114.5</td>
<td>113.5</td>
<td>-0.9%</td>
<td>114.5</td>
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<td>2.1%</td>
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<tr>
<td>1982</td>
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<td>-3.0%</td>
<td>113.5</td>
<td>113.6</td>
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<td>1983</td>
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<td>109.6</td>
<td>-1.0%</td>
<td>110.7</td>
<td>112.6</td>
<td>1.7%</td>
</tr>
</tbody>
</table>

Theil's U 0.007 0.006
Root Mean Squared Error 1.68 1.31

---

4 A 10 percent increase in price over the next 5 years would make the price of milk approximately equal to the current Australian price of 52 cents for 600 mls.
CHAPTER 5

CONCLUSIONS

5.1 The Usefulness of the Models

This report demonstrates that econometric analysis provides a satisfactory method for quantifying the factors which determine the per capita consumption of milk. The report also demonstrates that the estimated models can be used effectively for:

(1) historical analysis
(2) forecasting seasonal and annual sales
(3) policy analysis

In the context of historical analysis the elasticities from the estimated models can be used to isolate the past effects of the various policy variables and other factors. For example the annual model can be used to examine the extent the price increase in the period 1975 to 1983 affected the decline in per capita consumption of milk.

During this period per capita consumption dropped from 135 to 113 litres per capita (16 percent down) while the real price of milk increased by 138 percent. However, there was also a decrease in the proportion of children 0 to 14 years in the population from 29.4 to 25.9 percent, an increase in the generic advertising of milk and an increase in the competition from milk substitutes such as fruit juices. Using the elasticities from the annual model approximately three quarters of this decline can be attributed to the price increases with the remainder due to a change in age structure and to trend factors. The results indicate that advertising over this period had little effect in stimulating consumption levels.

The ex-post validations, where the models were used to predict outside the data interval, demonstrate both the quarterly and annual models are capable of providing accurate forecasts and hence have the potential to become useful policy analysis tools.

5.2 Comparison with Overseas Results

The estimates of the elasticities for price, income, age structure and the seasonal effects are reasonably consistent with the results from the overseas studies which were reviewed in Chapter 2. A possible explanation for the slightly more inelastic demand is that the New Zealand price for milk has been considerably lower than other countries. For example the April 1983 average retail price for 600ml of milk in New Zealand was 30 cents compared with 52 cents for Australia, 54 cents for U.K. and 55 cents for U.S.A.

5.3 Further Research

It is important to emphasise that this study only provides a preliminary analysis. Further model development and testing is required before the models can be used by the milk industry as an on-going planning tool.

This study has been solely concerned with analysing aggregate demand and useful extensions would be to explore regional demand and product type demand. Another valuable area for future research would be to adapt the models so they could be used to simulate the effects of policy changes and to explore the revenue implications of these policy simulations. This type of analysis could be similar to Strak and Gill's (1983, Chapter 4) simulation of the U.K. milk market.
REFERENCES


New Zealand Milk Board (1972-82), Annual Reports, 1972 to 1982.


Street, J.A. (1974), "Demand for Milk". Review of Marketing and Agricultural Economics 42(2) : 100-112.


U.S. Department of Agriculture (1970), "Dairy Situation" (monthly publication).

25.
Elaboration on the Partial Adjustment Process

The partial adjustment process is based on the assumption that consumers only partially adjust their consumption of milk in the current period. The structural model from which the reduced form model is derived consists of two equations. The first represents the desired consumption in period $t$.

$$Y_t^* = f(X_{1t}, ..., X_{nt})$$  \hspace{1cm} (1)

where $Y_t^*$ is the "desired" consumption

$X_{1t}, ..., X_{nt}$ is a set of independent variables such as price, income and age structure.

The second equation represents the partial adjustment process.

$$Y_t - Y_{t-1} = \alpha (Y_t^* - Y_{t-1}) + U_t$$  \hspace{1cm} (2)

where $Y_t$, $Y_{t-1}$ are actual consumption and $\alpha$ is a partial adjustment or inertia coefficient. It is assumed that the partial adjustment process or inertia effect is caused by the slowness of consumers to change old habits or by lack of consumer information.

Substituting (1) in (2) gives

$$Y_t = \alpha f(X_{1t}, ..., X_{nt}) + (1 - \alpha) Y_{t-1} + U_t$$  \hspace{1cm} (3)

which is the reduced form (or estimation form) of the partial adjustment model. The partial adjustment model was first suggested by Nerlove (1956).
## APPENDIX B

Observations Used for Estimation and Forecasting

### B.1 Quarterly Model Data

<table>
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<th>Quarter Year</th>
<th>CONS</th>
<th>PRICER</th>
<th>WAGER</th>
<th>AGE@</th>
<th>14</th>
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29.
### B.2 Annual Model Data

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### B.3 Data Sources

**CONS** = Consumption per head in litres. Pasteurized Town Milk Sales divided by the New Zealand Population. Sources: N.Z. Milk Board's Annual Reports (Table I) and Monthly Abstract of Statistics.

**PRICER** = Price of pasteurized milk per litre divided by the consumer price index for food. Sources: N.Z. Milk Board's Annual Reports and Monthly Abstract of Statistics.

**WAGER** = Real weekly wage of adult employees. Sources: Monthly Abstract of Statistics.

**AGE@14** = Percentage of Population 0 to 14 years. Sources: Monthly Abstract of Statistics.

The quarterly model data are of the January/March, April/June, July/September and October/December quarters while the annual model data are for the year ending 31 August.
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