THE DEMAND FOR MILK:

AN ECONOMETRIC ANALYSIS OF THE NEW ZEALAND MARKET

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PREFACE

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.

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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 investiga-
tion 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 distri-
bution of the population, the price of milk substitutes, consumer attitudes
towards such factors as the health and "goodness" of milk versus milk substi-
tutes, 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. Per-
haps 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.[1]

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 consu-
mer 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.

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[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.

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 inter-relationships 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 conclu-
sions 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 cumula-
tive 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[2], 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

$$\text{CONS} = b_0 + b_1\text{CONS}(-1) + b_2\text{PRICER} + b_3\text{WAGER} + b_4\text{AGE}\emptyset14 +$$
$$b_5\text{ADVR} + b_6D_1 + b_7D_2 + b_8D_3 + U$$

where

CONS	= pasteurized milk consumption per head per quarter
CONS(-1)	= previous period's consumption per head
PRICER	= price of milk per litre deflated by the CPI for food
WAGER	= real wage rate
AGE$\emptyset$14	= percentage of the population in the $\emptyset$ to 14 year old age group
ADVR	= advertising expenditure (adjusted for inflation)
D_1, D_2, 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.

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[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 1

Consumer Prices of Town Milk in New Zealand

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

SOURCE: New Zealand Milk Board Annual Reports 1972 to 1982.
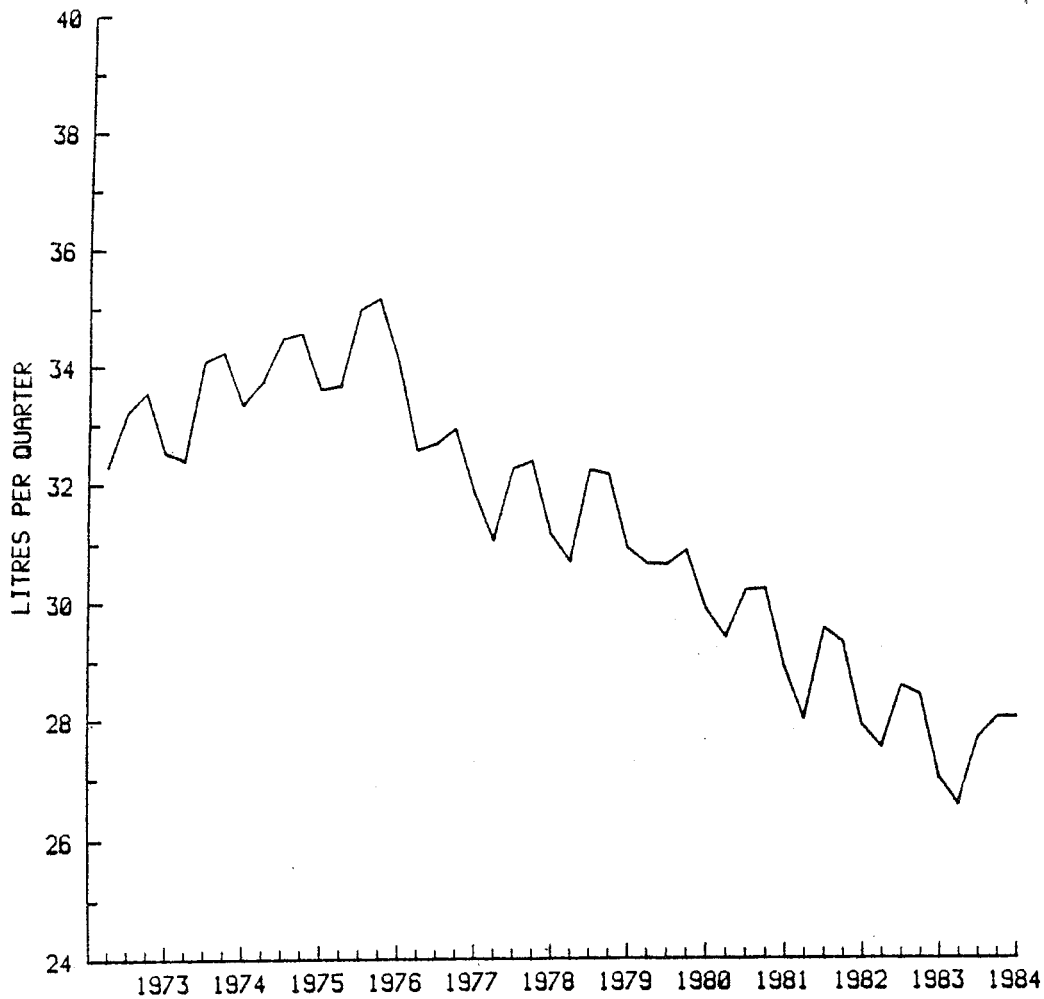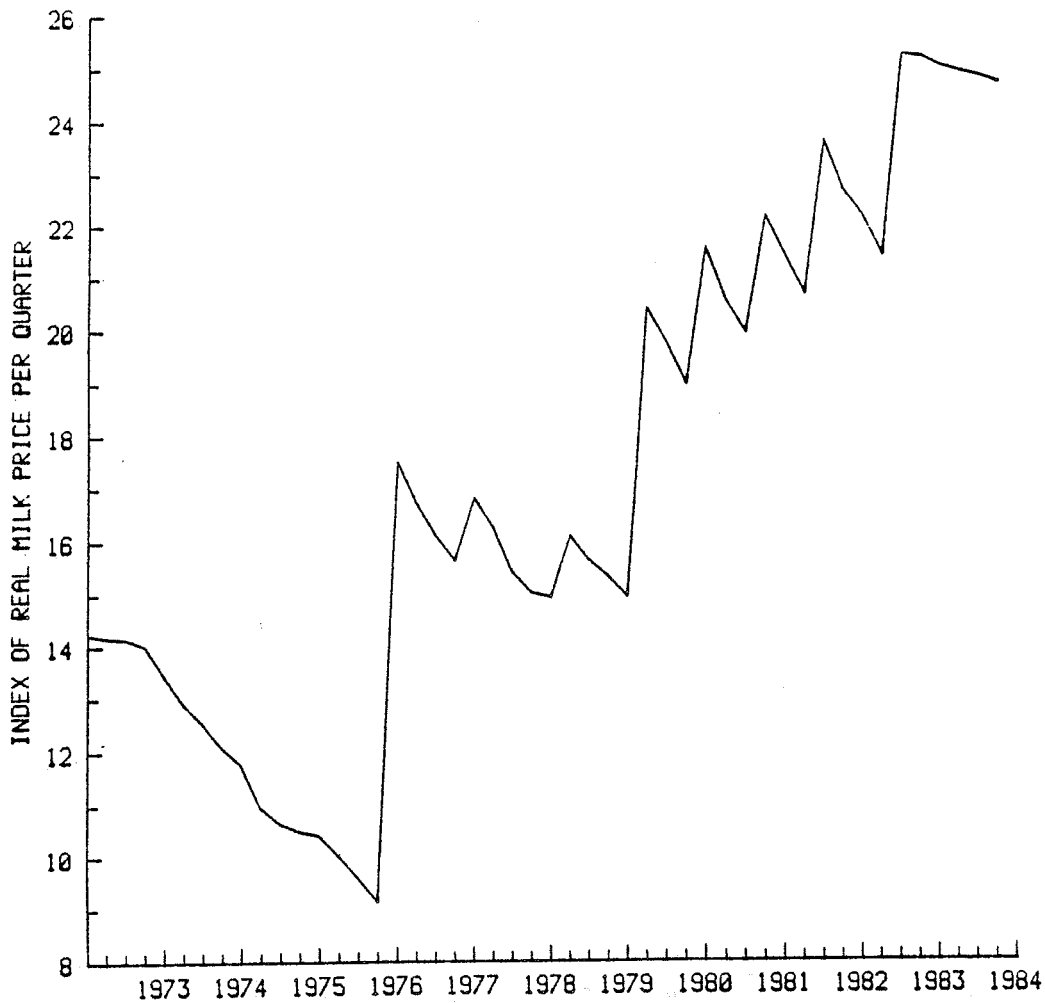
Figure 1:   QUARTERLY MILK CONSUMPTION PER HEAD

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 2

Advertising and Related Expenditure by the
New Zealand Milk Promotion Council

Year Ending March	$,000 (nominal)	$,000 (real)[a]
1978	223.0	413.3
1979	426.7	673.9
1980	353.6	463.6
1981	165.5	185.9
1982	473.8	473.8
1983 (estimated)	541.1	

[a] converted to 1982 dollars

4.1.2 Estimation Results

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

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

$$+ 0.188 \text{ AGE}\emptyset14 + 0.013 \text{ D}_1 + 0.056 \text{ D}_2 + 0.039 \text{ D}_3$$
$$\quad (3.25) \quad\quad\quad (3.23) \quad\quad (12.66) \quad\quad (10.36)$$

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

where the t statistics are given in brackets underneath the estimated coefficients; $\overline{R}^2$ 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[3]

CONS	= pasteurized milk consumption per head
CONS(-1)	= the previous period's pasteurized milk consumption per head
PRICER	= the price of milk per litre deflated by the consumer price index for food
AGE$\emptyset$14	= 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 $\overline{R}^2$ 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 unde-flated 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.

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[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.

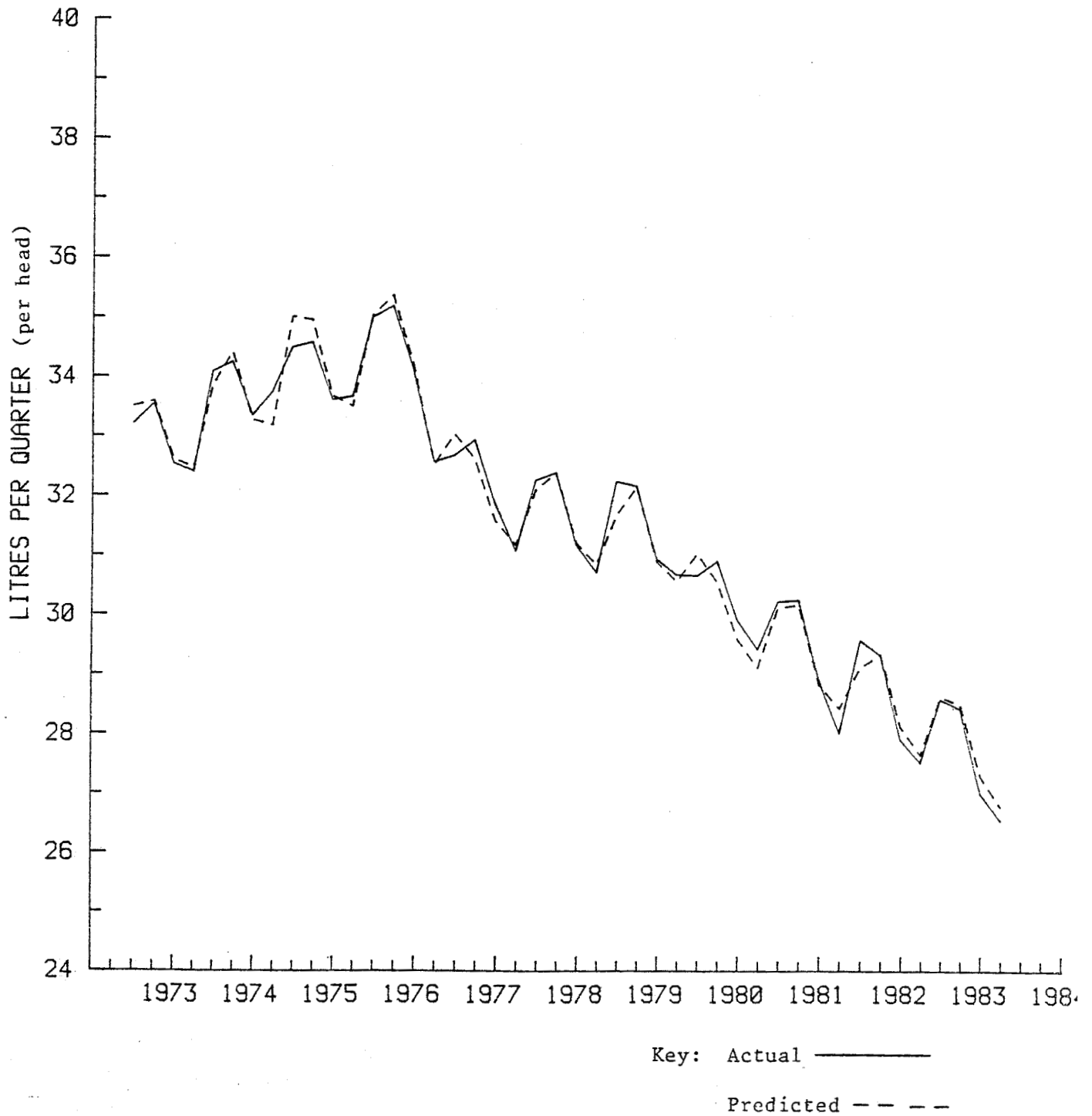Figure 3: QUARTERLY ACTUAL VS. PREDICTED VALUES

Key: Actual ——————

Predicted — — — —

TABLE 3

Estimation Results for Quarterly Models

Variable	Linear Models		Log–Linear Models	
	1. Final Specification	2. Initial Specification	1. Final Specification	2. Initial Specification
Constant	10.134 (5.10)**	10.848 (4.16)**	0.804 (4.01)**	1.111 (2.77)**
CONS(-1)	0.577 (10.21)**	0.578 (9.87)**	0.628 (10.15)**	0.628 (9.96)**
PRICER	-0.159 (-7.08)**	-0.160 (-6.91)**	-0.066 (-5.81)**	-0.069 (-5.80)**
AGEØ14	0.172 (3.16)**	0.169 (2.61)**	0.188 (3.25)**	0.193 (2.80)**
WAGER	–	-0.001 (-0.47)	–	-0.046 (-0.97)
D1	0.372 (3.26)**	0.376 (3.17)**	0.013 (3.23)**	0.014 (3.25)**
D2	1.648 (13.37)**	1.641 (12.85)**	0.056 (12.66)**	0.055 (12.25)**
D3	1.207 (11.72)**	1.203 (11.34)**	0.039 (10.36)**	0.038 (10.05)**
ADVR	–	-0.003 (-0.015)	–	-0.002 (0.31)
$\overline{R}^2$	0.989	0.989	0.987	0.986
	$F_{(6,37)}=662.2$	$F_{(8,35)}=473.2$	$F_{(6,37)}=527.2$	$F_{(8,35)}=384.3$
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 AGE∅14 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 <u>Forecasting Performance of the Quarterly Models</u>

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

Year Quarter		Linear Model			Log-Linear Model		
		Actual	Predicted	Error	Actual	Predicted	Error
1981	1	28.1	28.1	0.0%	28.0	29.2	4.2%
	2	29.6	30.2	0.2%	29.6	30.2	2.0%
	3	29.3	29.1	-0.7%	29.3	29.7	0.1%
	4	27.9	27.3	-0.7%	27.9	28.7	2.5%
1982	1	27.5	27.6	0.4%	27.5	28.9	5.1%
	2	28.6	29.4	2.7%	28.6	29.9	4.5%
	3	28.4	28.3	-0.3%	28.4	29.2	2.8%
	4	27.0	26.4	-2.2%	27.0	28.2	4.4%
1983	1	26.5	26.5	0.0	26.5	28.2	6.4%
Theil's U				0.0011			0.019
Root Mean Squared Error				0.47			1.11

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
4¢/pint or 7.0423¢/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
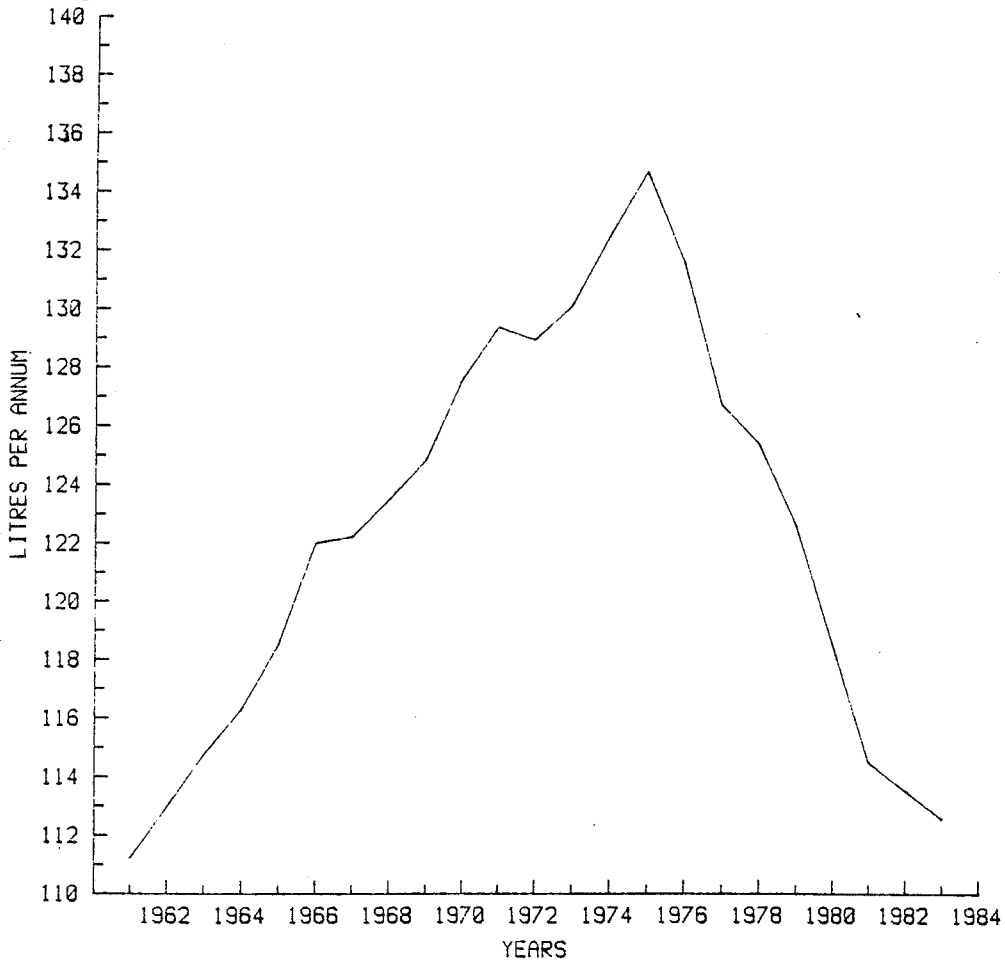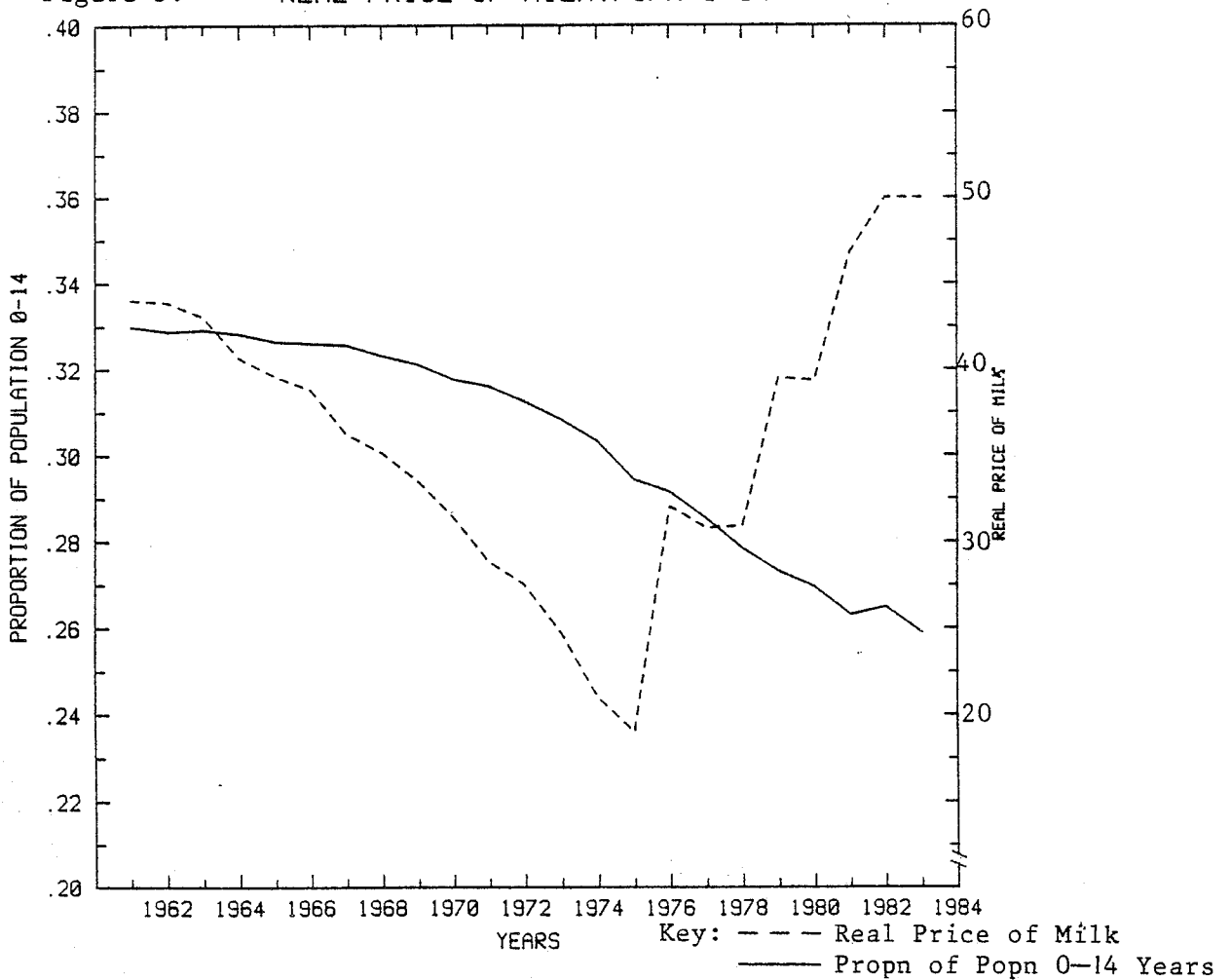
18. Figure 4: ANNUAL MILK CONSUMPTION PER HEAD

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. CONS $= 1.612 + 0.745$ CONS$(-1) - 0.064$ PRICER $+ 0.133$ AGEØ14
    (4.15) (10.12) (-3.76) (4.48)

    $\bar{R}^2 = 0.974$, F$(3,19) = 275.2$, DW $= 1.86$

    CONS $=$ pasteurized milk consumption per head

    CONS$(-1) =$ previous period's consumption per head

    PRICER $=$ price of milk per litre deflated by the CPI for food

    AGEØ14 $=$ 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. CONS $= 2.409 + 0.606$ CONS$(-1) - 0.067$ PRICER
    (5.80) (7.96) (-4.69)

    $+ 0.296$ AGEØ14 $+ 0.030$ TREND
    (5.05) (3.06)

    $\bar{R}^2 = 0.985$ F$(4,18) = 299.9$ DW $= 2.44$

TREND is a time trend $(1, 2, \ldots, 25)$

In this case CONS(-1), PRICER, AGEØ14 and 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

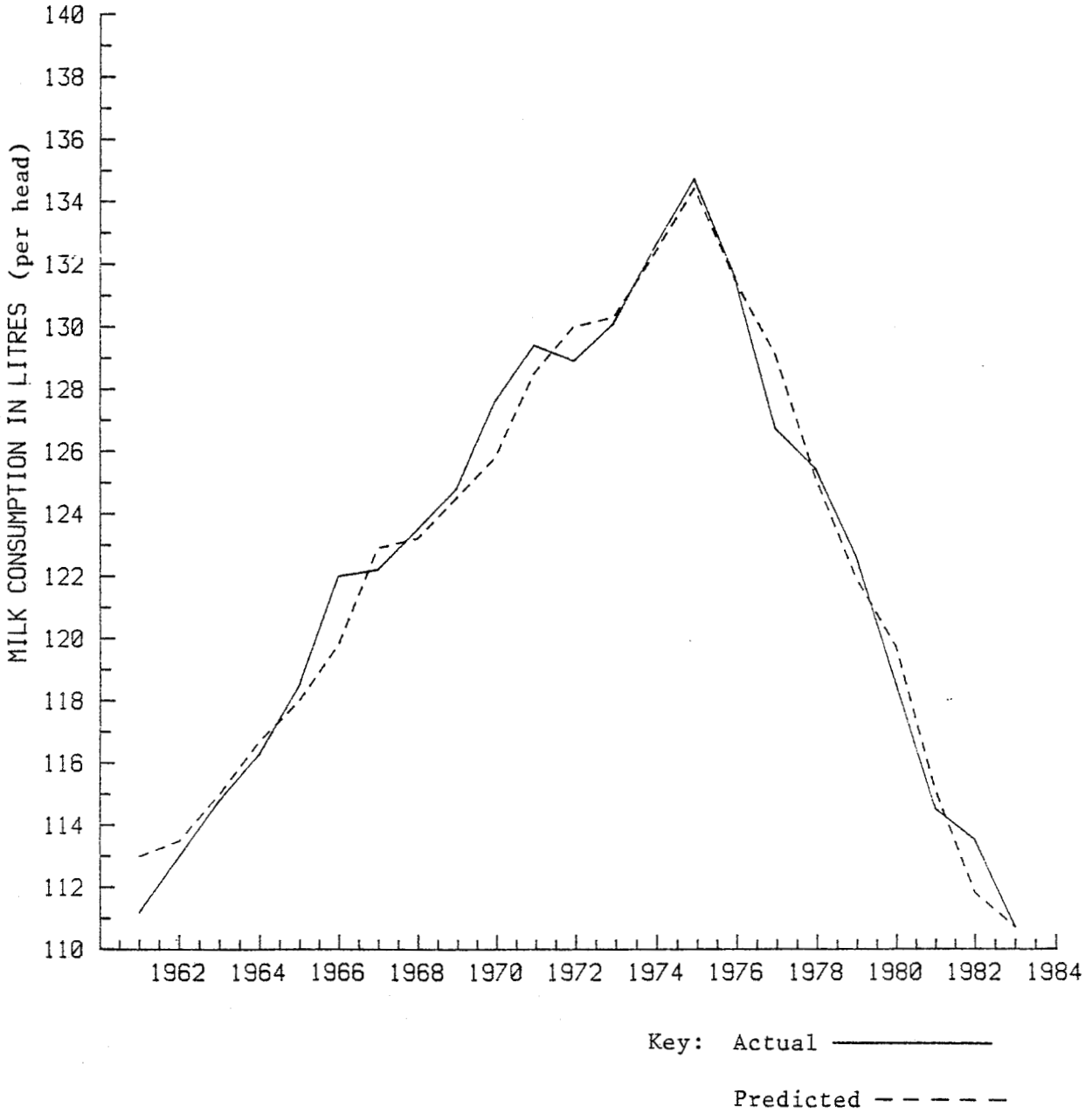Figure 6: ANNUAL MODEL ACTUAL VS. PREDICTED VALUE

Key: Actual ————————

Predicted — — — — —

TABLE 5

Estimation Results for Annual Models

Variable	Linear Models			Log-Linear Models		
	1. Final Specification	2. Final Specification (Trend Included)	3. Initial Specification	1. Final Specification	2. Final Specification (Trend Included)	3. Initial Specification
Constant	42.847 (2.27)*	6.247 (0.28)	-8.953 (-0.278)	1.612 (4.15)**	2.409 (5.80)**	2.247 (2.20)*
CONS(-1)	0.649 (6.46)**	0.556 (5.82)**	0.574 (5.54)**	0.745 (10.12)**	0.606 (7.96)**	0.619 (3.47)**
PRICER	-0.316 (-3.70)**	-0.309 (-4.12)**	-0.274 (-2.75)**	-0.064 (-3.76)**	-0.067 (-4.69)**	-0.061 (-1.40)
AGEØ14	0.387 (2.42)*	1.709 (3.17)**	1.957 (2.89)**	0.133 (4.48)**	0.296 (5.05)**	0.230 (0.87)
WAGER	–	–	0.022 (0.59)	–	–	-0.003 (-0.03)
ADVR	–	–	0.000 (0.49)	–	–	0.000 (0.46)
TREND	–	0.526 (2.55)*	0.519 (2.39)*	–	0.030 (3.06)	0.028 (1.23)
$\bar{R}^2$	0.974	0.981	0.975	0.974	0.985	0.904
F	$F_{(3,19)}=240.0$	$F_{(4,18)}=233.8$	$F_{(6,16)}=142.7$	$F_{(3,19)}=275.2$	$F_{(4,18)}=299.9$	$F_{(6,16)}=35.4$
Number of Observations	23	23	23	23	23	23

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.

21.

5 and 10 percent per year.[4]

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

Year Ending	Linear Model			Log—Linear Model		
	Actual	Predicted	Error	Actual	Predicted	Error
1979	122.6	120.0	—2.1%	122.6	120.5	—1.7%
1980	118.5	117.8	—0.6%	118.5	118.0	—0.4%
1981	114.5	111.7	—2.4%	114.5	113.0	—1.3%
1982	113.5	107.9	—4.1%	113.5	109.5	—3.6%
1983	110.7	106.7	—3.6%	110.7	108.3	—2.2%
Theil's U			0.015			0.010
Root Mean Squared Error			3.56			2.40

(b) Trend Included

Year Ending	Linear Model			Log—Linear Model		
	Actual	Predicted	Error	Actual	Predicted	Error
1979	122.6	120.9	—1.3%	122.6	121.8	—0.7%
1980	118.5	119.1	0.5%	118.5	120.1	1.2%
1981	114.5	113.5	—0.9%	114.5	115.9	2.1%
1982	113.5	110.6	—3.0%	113.5	113.6	0.1%
1983	110.7	109.6	—1.0%	110.7	112.6	1.7%
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 estima-
ted 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]

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[5] Monthly Abstract of Statistics, Table 21.07 p. 94, September 1983,
    Department of Statistics.

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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.

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APPENDIX A

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.

$$Y^*_t = f(X_{1t}, \ldots, X_{nt}) \tag{1}$$

where Y^*_t is the "desired" consumption

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

The second equation represents the partial adjustment process.

$$Y_t - Y_{t-1} = \alpha (Y^*_t - Y_{t-1}) + U_t \tag{2}$$

where Y_t, Y_{t-1} are actual consumption and α 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

$$Y_t = \alpha f(X_{1t}, \ldots, X_t) + (1 - \alpha) Y_{t-1} + U_t \tag{3}$$

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

Quarter Year		CONS	PRICER	Variable WAGER	AGEØ14
1972	1	32.3	14.2	101.2	30.4
	2	33.2	14.2	100.0	30.7
	3	33.6	14.1	99.1	31.0
	4	32.5	14.0	105.7	31.2
1973	1	32.4	13.4	103.7	31.1
	2	34.1	12.9	103.2	31.0
	3	34.2	12.5	107.5	30.9
	4	33.3	12.1	105.4	30.8
1974	1	33.7	11.8	105.6	30.7
	2	34.5	10.9	103.0	30.6
	3	34.6	10.6	111.6	30.5
	4	33.6	10.5	109.0	30.3
1975	1	33.7	10.4	109.1	30.1
	2	35.0	10.0	105.0	30.0
	3	35.2	9.6	106.8	29.8
	4	34.1	9.1	103.5	29.6
1976	1	32.6	17.5	102.8	29.4
	2	32.7	16.7	104.8	29.3
	3	32.9	16.1	101.7	29.3
	4	31.9	15.6	102.4	29.1
1977	1	31.1	16.8	106.1	29.1
	2	32.3	16.2	101.7	29.1
	3	32.4	15.4	98.7	28.9
	4	31.2	15.0	100.0	28.5
1978	1	30.7	14.9	100.8	28.3
	2	32.2	16.1	99.5	28.1
	3	32.2	15.6	103.6	28.0
	4	30.9	15.3	102.5	27.8
1979	1	30.7	14.9	106.0	27.7
	2	30.7	20.4	103.4	27.6
	3	30.9	19.8	98.9	27.4
	4	29.9	19.0	105.1	27.3
1980	1	29.4	21.6	105.0	27.2
	2	30.2	20.6	102.1	27.1
	3	30.2	19.9	102.9	27.0
	4	28.9	22.2	107.5	27.0
1981	1	28.0	21.4	108.8	26.9
	2	29.6	20.7	106.2	26.7
	3	29.3	23.6	107.7	26.6
	4	27.9	22.7	109.4	26.4
1982	1	27.5	22.2	109.7	26.3
	2	28.6	21.4	105.4	26.2
	3	28.4	25.3	102.0	26.1
	4	27.0	25.2	99.3	26.0
1983	1	26.5	25.1	98.5	25.9

B.2 Annual Model Data

Year Ending	Variable			
	CONS	PRICER	AGEØ14	WAGER
1960	110.5	44.4	32.0	155.2
1961	111.2	44.0	33.0	156.3
1962	113.0	43.9	32.9	159.5
1963	114.8	43.1	32.9	160.8
1964	116.3	40.6	32.8	156.3
1965	118.5	39.6	32.6	161.8
1966	122.0	38.8	32.6	163.0
1967	122.2	36.2	32.6	159.9
1968	123.5	35.1	32.3	161.0
1969	124.8	33.5	32.1	162.6
1970	127.6	31.4	31.8	172.1
1971	129.4	28.8	31.6	194.0
1972	128.9	27.5	31.2	201.8
1973	130.1	24.7	30.8	202.8
1974	132.5	21.0	30.3	206.7
1975	134.7	19.0	29.4	212.6
1976	131.6	32.0	29.1	200.4
1977	126.7	30.9	28.5	194.6
1978	125.4	30.9	27.8	199.5
1979	122.6	39.5	27.3	196.8
1980	118.5	39.3	26.9	193.2
1981	114.5	46.8	26.3	197.7
1982	113.5	50.0	26.5	196.8
1983	112.6	50.0	25.9	196.8

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 1) 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.

AGEØ14 = 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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