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Lincoln College

THE THEORY AND ESTIMATION OF ENGEL CURVES : SOME ESTIMATES FOR MEAT IN NEW ZEALAND

by

C.A. Yandle

Technical Paper No. 3

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THE AGRICULTURAL ECONOMICS RESEARCH UNIT

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Agricultural Economics Research Unit Technical Paper No. 3

P R E F A C E

This paper is one of a series based on original research conducted by Mr Yandle at Lincoln on the New Zealand Meat Market. In the course of this work Mr Yandle conducted a questionnaire survey of 300 families in Christchurch in which heads of families were asked to indicate their basic preferences for different meats, and to record their actual expenditure on meat along with family income for a given week.

The results of this survey were published last year in "A Survey of Christchurch Consumer Attitudes to Meat" Agricultural Economics Research Unit Research Report No. 43.

In the present paper Mr Yandle deals at a rather more technical level with the analysis of this data in particular with the derivation of Engel Curves showing the relationship between consumer's incomes and their purchases of meat. The paper should prove of interest to students of marketing in general and those concerned with the meat trade in particular.

We should like to acknowledge the financial help received from the Canterbury Frozen Meat Company and the New Zealand Pig Producers' Council in support of this work.

B.P. Philpott

November 1968

EDITORIAL NOTE

This publication is one of a series based on a thesis by Mr C.A. Yandle entitled "An Econometric Study of the New Zealand Meat Market", written for the Degree of Master of Agricultural Science at Lincoln College.

The Papers in this series will be:-

A.E.R.U. Publication No. 43 "Survey of Christchurch Consumer Attitudes to Meat".

A.E.R.U. Technical Paper No. 3, "The Theory and Estimation of Engel Curves: Some Estimates for Meat in New Zealand".

A.E.R.U. Technical Paper No. 7, "An Econometric Model of the New Zealand Meat Market".

A.E.R.U. Discussion Paper No. 8, "Quarterly Estimates of New Zealand Meat Price, Consumption and Allied Data, 1946-1965".

In this series of publications no attempt has been made to alter the original thesis presentation, thus where, in a particular publication, a section of the thesis is not presented, page numbering has not been corrected and foot-note cross references may in some cases refer to page numbers not shown in the same publication.

This publication comprises Chapter 3 and Appendix B of the thesis. The subject is the estimation of Engel curves from survey data. A review is made of the appropriate economic theory, and the application of that theory to market generated data. Estimates of Engel curves for a variety of meats are presented. Data were drawn from a postal questionnaire survey of households in Christchurch, New Zealand.

THE THEORY AND ESTIMATION OF ENGEL CURVES: SOME ESTIMATES FOR MEAT IN NEW ZEALAND

Introduction

In the previous chapter the method of sample selection, and individual question analysis of replies from the postal survey of Christchurch consumers was discussed. This chapter will be concerned with the use made of the survey data to estimate Engel curves and income - expenditure elasticities. The first part of this chapter will be concerned with the theoretical properties of Engel curves, and the data transformations which were required if the data were to comply with these properties. Section Two will be concerned with the functional forms appropriate for the estimation of the curves, and with related statistical problems. The curves and elasticities estimated will then be presented.

Theoretical Requirements of the Engel Curve

An Engel curve expresses the relationship between a single consumer's income, and his consumption or expenditure on a particular good. It is therefore a special application of the theory of consumer choice, or consumer demand. Of particular interest to this area of study are the following tenets of the theory of consumer demand:

(a) The consumer's preferences for different goods are fixed (given), and assumed unchanging over the period of analysis.

(b) Quantities purchased are related to prices and income, the value of purchases being subject to the constraint that Total Expenditure = Total Income, savings being assumed part of expenditure.

(c) The consumer will arrange his pattern of expenditure in a rational manner, that is he will endeavour to maximise his satisfaction or utility.

Consumer demand theory therefore considers the single consumer maximising a utility function u(q) subject to the constraint that pq=m, where q is a column vector of quantities, p a row vector of prices, and m (a scalar) the income of the consumer. From this theory the normal demand equations of the individual can be derived, i.e.;

$$q = d(p,m)$$

which is the basis of most empirical work in demand analysis.[1] The theory is of a static nature, and before applying it to the problem on hand, several aspects including its static nature, must be carefully examined.

An exercise in statics does not allow for effects on demand of stock holding or of lagged changes in demand due to previous price or income changes. Equally Friedman's permanent income theory which is dynamic in nature, could be significant in explaining demand.[2]

The generalisation from one consumer to many, implicit in empirical demand studies, can have disadvantages. Individual consumers may have markedly different preferences, and hence different indifference curves, for the same combination of goods. An overall community measure therefore becomes less accurate and meaningful.

In time-series studies, where the observations for the analysis are spread over a period of time, the assumption that consumers' preferences remain unchanged within the period of analysis can be of limited usefulness. Some consumers will make purchases which can be best described as

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1. See: P.A. Samuelson, Foundations of Economic Analysis, Harvard University Press, Cambridge Massachusetts, 1958, pp. 92-100. for an example of this derivation.
2. M. Friedman, A Theory of the Consumption Function, Princeton University Press, Princeton, 1957.

experimental within any time period; and these purchases may modify the consumer's existing preference schedule within the period of study.

These are but a few of the difficulties with which the empirical researcher is faced when entering the field of demand analysis. Ceteris paribus assumptions covering these difficulties are often not valid. The limitations of demand theory will therefore form a large part of this discussion, along with the importance of these limitations as they apply to this research.

This study is concerned, however, only with the income - expenditure relationship, with the ceteris paribus assumption applied to prices. The effect of meat prices on expenditure can in fact be assumed constant over all data observations because the survey took place at one point of time in one locality. The functional relationship can therefore be expressed as:

$q = d'(m)$

or

$q_i = d_i'(m) \; ; \; i = 1.n$ where there are n commodities

This is the income-consumption relationship.

Similarly the income-expenditure relationship is:

$p_i q_i = d_i''(m) \; ; \; i = 1,n$

Both income-expenditure and income-consumption relationships which have been derived from budget study data have become known as 'Engel Curves'; however, because this study is concerned only with the income-expenditure relationship, the term 'income-expenditure' will be used, even though the analytical techniques discussed can be applied to both income-expenditure and income-consumption relationships. The reasons for confining this analysis to income-expenditure relationships is discussed later.[1]

1. Pp. 52-53.

Engel was not the first person to study these relationships[1] but he was the first person to formulate a general law about the manner in which expenditure on a group of goods changes with income changes. Engel's general law, which he derived from empirical data, could be stated as "The poorer a family, the greater the proportion of total expenditure that must be devoted to food".[2] Other 'laws' have been attributed to Engel, but this was the only general relationship he deduced.

More recently goods have been classified in three distinct categories:

(a) Inferior goods - the consumption of which declines both relatively and absolutely to income, as income rises.

(b) Necessities - the consumption of which declines only relatively as income rises.

(c) Luxuries - the consumption of which increases both relatively and absolutely to income, as income rises.

Originally expressed in terms of 'budget-proportion', these three groupings are now usually presented in terms of elasticities.

If Y_i = Income elasticity of expenditure for the i^{th} good, then if the i^{th} good is:

an inferior good	$Y_i \leqslant 0$
a necessity	$0 \leqslant Y_i \leqslant 1$
a luxury	$Y_i \geqslant 1$

Engel's general conclusion indicates that the size of Y_i for the individual consumer will depend on his current level of income. Thus

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1. See: G.J. Stigler, "The Early History of Empirical Studies of Consumer Behaviour", Journal of Political Economy, Vol. 62, No. 2, April 1954, pp. 95-113.

2. Ibid, p. 98.

a good can be a luxury to one consumer (low income) and an inferior good to another (high income), where the only difference between the consumers is one of income. It may therefore be expected, as a general approximation, that the size of the income elasticity of expenditure will vary inversely with income.

Consumer demand theory analyses the individual consumer maximising a utility function, and then generalises this concept to the demand curve of the community. This generalisation is recognised as not being completely acceptable, but as an approximation the best available. There will always be some causes of inter-personal differences in expenditure patterns which are unmeasurable and cannot therefore be included in an empirical study. Unexplained variation between the expenditure patterns of individual consumers must therefore always be expected. With the analysis of family budget data, the problem is made more difficult because the purchasing unit is usually the household and not the individual.[1] Influences such as the age of family members, sex, and the number of persons in the household become important. In addition, it is usually not the same person who does all the buying for the household. In this particular study the household will be considered as the purchasing unit, while recognising that the generalisation to many households has the same disadvantages as generalising from one consumer to many. Factors which make household consumption patterns different will now be discussed and if possible eliminated from the data in an endeavour to isolate the effect of income for direct measurement.

Age, sex structure, and the number of people in the household will affect the consumption pattern. These three factors must in some measure be considered together. In considering the consumption of a particular

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1. S.J. Prais and H.S. Houthakker, The Analysis of Family Budgets, Cambridge University Press, London, 1955, p. 11.

commodity a 'consumer unit' scale can be derived.[1] Any one consumer unit scale is however not applicable to all commodities, hence a simple weighting system is usually not satisfactory. While it is possible to specify the daily requirements of all age-sex groups for a particular good (e.g. meat), if a system of weights is derived on the basis of these requirements the possibility is ignored that correspondingly more <u>income</u> may be required for another good (e.g. baby food). This second requirement can have the effect of reducing meat consumption below what is would otherwise have been for the rest of the household. Some researchers approach this problem empirically, attempting to determine the 'cost' of a child'.[2] Brown[3], in a review of this problem shows that a general behaviour equation of the following form may be expected:

$$\frac{X_{ir}}{\sum_j \beta_{ij} N_{jr}} = f\left[\frac{M_r}{\sum_j \alpha_j N_{jr}}\right]$$

where:

X_{ir} = Expenditure on the i^{th} commodity by the r^{th} household.

N_{jr} = Number of persons in the r^{th} household belonging to the j^{th} age-sex group.

β_{ij} = A coefficient depending on the i^{th} commodity and the j^{th} age-sex group, assumed constant over all r households.

M_r = Total net income of the r^{th} household.

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1. Given the j^{th} (j=1 to m) age-sex group's requirements for the i^{th} product, specified for all j, then a 'consumer unit' index can be derived, e.g. dividing household consumption by number of persons in the household to put data in 'per person' form implicitly assumes an index where all j coefficients = 1.

2. A.M. Henderson, "The Cost of a Family", <u>Review of Economic Studies</u>, Vol. 17(2), 1949-1950, pp. 127-148.

3. J.A.C. Brown, "The Consumption of Food in Relation to Household Size and Income", <u>Econometrica</u>, Vol. 22, 1954, pp. 444-460.

α_j = A coefficient depending only on the j^{th} age-sex group, again assumed constant over all households.

The left hand side of the equation measures household expenditure on the i^{th} good per equivalent adult, using an "equivalence" (or consumer unit) scale which can be different for each commodity, i.e. β_{ij} the weight of the j^{th} age-sex group for the i^{th} commodity can be different for each of the i commodities in the budget. As expressed in the equation, the left-hand side is a function of the net income per equivalent adult where α_j is the 'income' weight for the j^{th} age-sex group's 'income' requirement. The income requirement weights (α_j's) will thus be a weighted average of the specific scales (i.e. the β_{ij}'s weighted by their budget proportion).

A fully satisfactory allowance for household structure can therefore be very difficult, and its worth is doubtful because the assumption that α_j and β_{ij} are constant is again limiting. Additional information would also be required in the use of results. Application of elasticities derived by this method would require a description of the age-sex distribution of the population being sampled before any policy recommendations could be made. Secondly, the requisite data collection to make accurate assessment of α_j and β_{ij} and the budget proportions would be a large project in itself. A compromise was therefore adopted in this research, with two types of models being calculated. These models were:

(a) Expenditure and income were calculated 'per person' - i.e. all age-sex groups were given the same expenditure and income weights without regard to different dietetic requirements.

(b) Expenditure and income were calculated per 'consumer unit', the scale of weights for which was calculated from a chart of normative daily meat and fish requirements, provided by the Home Science School, Otago University.[1]

Other factors which could have affected expenditure patterns between household such as occupation, location, and possible price differences paid for the same good, have been ignored in this study. Any location and price differences would be small because in this study the households were chosen from the one metropolitan area. Meat, unlike some professional services, is not charged according to income.

When planning the survey it was hoped that an estimate of the importance of occupation on meat expenditure could be made. This was not possible because the respondents' replies to the question asking occupation were not sufficiently precise. If occupation has a significant influence on meat expenditure its neglect will result in greater unexplained variance in the estimated equations. If the estimated equations are statistically unsatisfactory the influence of occupation could therefore be part of the reason. In the application of the estimated income-expenditure coefficients for policy purposes it must be assumed that the sample reflected the New Zealand distribution of occupational type.

Of considerable importance in budget studies is the problem of different qualities of the same good. Theil[2] and Houthakker[3] discuss this problem in detail demonstrating that price differences for substantially the same good may be taken as an indication of quality differences. Prais and Houthakker[4] in analysing the problem for direct

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1. Chapter 2, pp. 39-40.
2. H. Theil, "Qualities, Prices, and Budget Enquiries", Review of Economic Studies, Vol. 19, No. 3, pp. 124-127.
   See also: H. Theil et al, Operations Research and Quantitative Economics, McGraw-Hill, New York, 1965, pp. 248-249.
3. H.S. Houthakker, "Compensated Changes in Quantities and Qualities Consumed", Review of Economic Studies, Vol. 19, No. 3, pp. 155-164.
4. S.J. Prais and H.S. Houthakker, op. cit., pp. 109-124.

application to the analysis of family budgets show that the expenditure elasticity is equal to the quantity elasticity plus the quality elasticity, i.e. if change in a consumer's expenditure on a good is composed of change in consumption (quantity) and quality, then for the i^{th} good;

$$\partial V_i = P_i \partial Q_i + Q_i \partial P_i$$

where:

V_i = Expenditure on the i^{th} good.

Q_i = Quantity purchased of the i^{th} good.

P_i = Quantity of the i^{th} good purchased as indicated by average price.

V_o = Income level.

hence it can be shown that:

$$\frac{V_o}{V_i} \cdot \frac{\partial V_i}{\partial V_o} = \frac{V_o}{Q_i} \cdot \frac{\partial Q_i}{\partial V_o} + \frac{V_o}{P_i} \cdot \frac{\partial P_i}{\partial V_o}$$

which is the result stated above.

In relation to the present study this result has importance. Each meat type is composed of a variety of grades (or qualities) of carcase, and within that carcase are many cuts, each of different quality again. As income rises, the consumer can not only change from one type of meat to another, he can change to a higher grade of meat within the same type, and higher quality cuts within the same grade. To calculate Engel curves from consumption data ignores the above substitution within the broad classes considered, and to attempt complete specification of each quality and cut of meat consumed would be virtually impossible. In view of the above, and the fact that the replies to the budget question were satisfactory only for expenditure on each meat, it was decided to calculate all relationships in terms of expenditures rather than quantities. This allowed the total change due to income to be estimated, and yet did not decrease the use of the derived elasticities.

Family size can affect meat expenditure other than as a linear progression. This is normally referred to as 'scale effects', and results from a piece of meat being used more efficiently when the household numbers increase.[1] To test whether scale effects were important in meat expenditure a further group of models were estimated which included household size as a separate variable.

Another problem considered was whether substitution between meats should be allowed for. Prais[2] shows that there are two aspects to this problem:

(a) Is the derived coefficient related to a substitution elasticity?

(b) Does the introduction of the substitute lead to a 'better' estimate of the income elasticity?

Prais is of the opinion (as are Allen and Bowley[3]) that the coefficient does not give an estimate of the substitution relationship, and that it causes the income elasticity to be underestimated. Estimates of these relationships were therefore not attempted. No attempt has been made in this study to allow for dynamic effects. Consumers' stock changes were thought to be unlikely to affect expenditure on meat in New Zealand and adjustment lags would have doubtful meaning in a cross-section study. While parameter estimates formulated using the permanent income theories would have been interesting, they were not attempted because of the difficulties associated with defining the income variable.

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1. See: S.J. Prais and H.S. Houthakker, op. cit., pp. 146-152.
2. S.J. Prais, "Non-Linear Estimates of Engel Curves", Review of Economic Studies, Vol. 20(2), pp. 98-99. Also: S.J. Prais and H.S. Houthakker, op. cit., p. 102.
3. R.D.G. Allen and A.L. Bowley, Family Expenditure, King and Son, London, 1935, pp. 89-96.

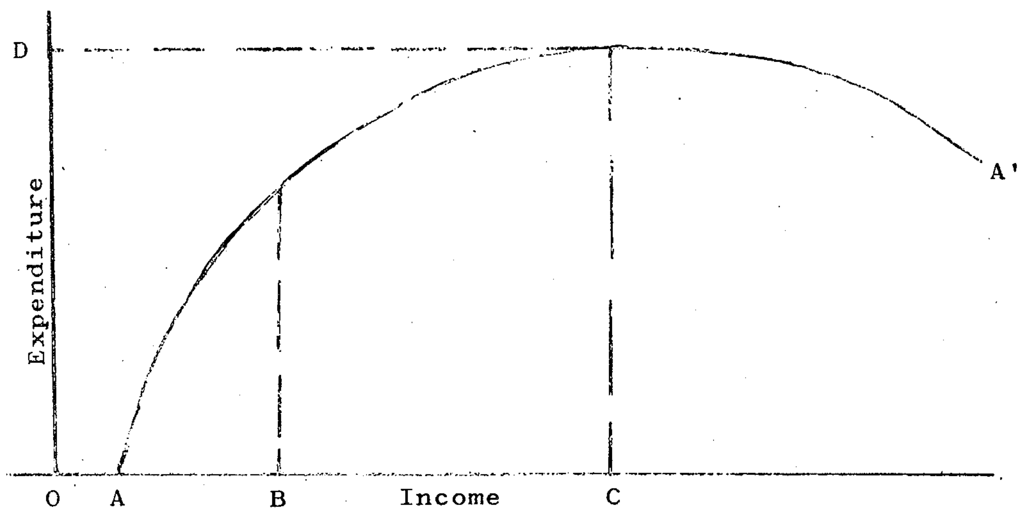
Appropriate Estimating Functions

Earlier sections of this chapter have described the general income-expenditure relationship which may be expected *a priori*. In this section the general shape of the Engel curve will be defined, and a discussion of appropriate mathematical functions for Engel curve estimation will follow. Some computational problems will also be considered.

The general shape of the Engel curve can be represented as shown in Diagram 3.1.

DIAGRAM 3.1

THE GENERALISED ENGEL CURVE.



In Diagram 3.1 A-A' represents an Engel curve with an 'initial income' level of OA. The initial income indicates the level of income necessary before the consumer begins buying the good. The three phases of the curve, as income rises, are; A-B indicating a luxury good, B-C a necessity, and beyond C an inferior good. From A to B, the income-expenditure elasticity (Y_i) is greater than unity, tending to unity as income rises. B indicates the point where $Y_i = 1$. Similarly C indicates the point where $Y_i = 0$. D shows the level of maximum expenditure (or satiety), occurring at income level C. With the range of incomes in the community, not all goods will exhibit all phases of the Engel curve. This point is discussed with respect to the estimation of Engel curves for meat, later.

Prais[1] examines in detail the general shape of the Engel curve, and the mathematical functions appropriate for its estimation. In a later work, Prais and Houthakker[2] examine further the implications of the functions available. These authors and Goreaux[3] consider in particular the following functional forms:[4]

(a)	Double log	$\log_e V_i = a + b \log_e V_o$
(b)	Sigmoid	$\log_e V_i = a - b/V_o$
(c)	Single log	$V_i = a + b \log_e V_o$
(d)	Linear	$V_i = a + b V_o$
(e)	Hyperbola	$V_i = a - b/V_o$

where V_i = expenditure on the i^{th} good

V_o = net income

a and b = parameters to be determined.

It is assumed that one of the methods of allowing for household size has already has already been used to transform the data.

Each mathematical function is equivalent to a different definition of the shape of the Engel curve. The problem is thus one of choosing between alternative definitions to find the one closest to what *a priori*

1. S.J. Prais, *op. cit.*, pp. 88-93.
2. S.J. Prais and H.S. Houthakker, *op. cit.*, pp. 87-103.
3. L.M. Goreaux, "Income and Food Consumption", *Monthly Bulletin of Agricultural Economics and Statistics*, Vol. 9, No. 10, pp. 1-13.
4. These equation forms will all be stochastic, but to simplify presentation the random error will not be shown. This procedure will be adopted throughout this study. Similarly natural logarithms will in all cases be used and henceforth assumed.

the Engel curve is expected to be. No one function exhibits all the properties of an Engel curve, and hence gives a clear cut solution. Some, however, prove to be more suitable than others. Briefly, the functions imply the following assumptions:

(a) Double log. This function is one of constant elasticity over all income ranges, with no initial income and a satiety level at infinite expenditure and income. As all the data must be transformed into logarithms if the double log function is to be used, there is often a problem where for a particular household the expenditure on a good equals zero, because it is not possible for a value to be placed on the logarithm of zero.[1]

(b) Sigmoid. As above, this function has no defined initial income level, but the elasticity size does vary inversely with income level. The problem of finding the logarithm of zero also occurs with this function. Satiety is reached only when income reaches infinity. The curve asymptotically reaches a saturation level of expenditure defined by the value of the constant a.

(c) Single log. This curve has an initial income which is always positive, and asymptotically approaches a satiety level of infinity at infinite income. The function corresponds to the assumption that the marginal propensity to consume is inversely proportional to income, and the expenditure elasticity varies inversely to expenditure (and hence by the model's specification with income).

(d) Linear. This function assumes a constant marginal propensity to consume, and that the expenditure elasticity tends to unity as income tends to infinity. The initial income level is indeterminate, and can in fact show positive expenditure at zero income.

1. A method of surmounting this problem is reported by: B.F. Massell and R.W.M. Johnson, "African Agriculture in Rhodesia; An Econometric Study", Rand Report R-443-RC, 1966, pp. 54-55.

Satiety level occurs at infinity for both variables.

(e) Hyperbola. This function exhibits an initial income equal to ($^b/_a$) and a satiety level of expenditure equal to the value of the constant a at infinite income. The curve also assumes that the marginal propensity to consume is proportional to the inverse of the square of income, and that the elasticity declines as income rises.

All these functions present a problem where $Y_i > 0$ i.e. where good i changes from a necessity to an inferior good, and hence reaches a satiety level of expenditure. On *a priori* grounds, whether this upper limit to expenditure is meaningful or not depends largely on the type of good. Motor cars, for example, can have very high and continuously rising levels of expenditure, as the consumer can improve the quality of his vehicle, without ever acquiring a second car. Thus not in all cases is a satiety level meaningful at less than very high incomes. With foods, considerable quality substitution is possible within broad food types. Thus provided care is taken not to extrapolate past the data observations, this problem of a function not having a satiety level before infinite income is reached need not be a serious limitation.

Another problem arises where the functional forms restrict satiety to an infinite level of income, that is they do not allow a good to change from a necessity to an inferior good as income rises. If a good shows inferior characteristics over the majority of observations, it will be calculated as inferior over the whole range of incomes. Generally, the more usual situation is for a good to be either in the luxury/necessity group, or the inferior group, over normal income ranges. The problem thus becomes less serious, but is still present.

On the basis of the differences in the assumptions involved, and on empirical investigation, the following general statements can be made regarding the estimating functions. Firstly, it is always possible to get a better estimating function that the linear form. A double log (constant elasticity) function is useful only over narrow income ranges because a priori the value of the elasticity is expected to decline as income rises. Double log functions therefore have their main use in studies involving specific income groups (e.g. 'Middle Class' households). Finding the log of zero values for expenditures can still present a problem, but as mentioned earlier this is not insurmountable.

The sigmoid curve which also requires the dependent variable to be transformed into logarithms has no defined initial income level and therefore its use is also limited. Of the remaining two functions (single-log and hyperbole), the choice is more difficult. Neither function is satisfactory in all respects. For food however the single-log equation appeared the more satisfactory.[1] Food expenditure elasticities usually decline inversely proportionately to income. With the single log equation the expenditure elasticity is inversely proportional to the level of expenditure (V_i) and therefore to income. This function is used throughout the study. Some of the uses and implications of this function will now be explored in detail.

The initial income level, or level of income necessary before expenditure on the commodity will begin, and can be shown to be:

$$\exp(-{}^{a}/_{b})$$

i.e. it is the value of V_o when $V_i = 0$.

Thus with the function:

$$V_i = a + b \log V_o.$$

when $V_i = 0$,

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1. S.J. Prais and H.S. Houthakker, op. cit., pp. 93-103.

then $\quad -{}^{a}/_{b} = \log V_o$

therefore $\exp(-{}^{a}/_{b}) = V_o$.

This is of course not applicable to an inferior good (where b is negative). The value so calculated would be the point where consumption of the good ceased, i.e. the maximum income.

The function allows for a 'saturation' level to be reached only at an infinite level of income for other than inferior goods. Care must therefore be taken in extrapolating past actual observations used in estimating equations. Allowance is made for a good to change from being a luxury at low income, to a necessity at high income. There is, therefore, a problem in specifying the market elasticity. Prais and Houthakker[1] show that the aggregate (or market) income elasticity of expenditure of the i^{th} product can be derived as follows;

Let V_i = Aggregate expenditure on the i^{th} product by all consumers.

V_o = Aggregate income of all consumers.

v_{ir} = Expenditure on the i^{th} product by the r^{th} consumer.

v_{or} = Income of the r^{th} consumer.

Then $V_i = \sum_r v_{ir}$, $V_o = \sum_r v_{or}$ for r consumers.

The aggregate income-expenditure elasticity is therefore:

$$\frac{V_o}{V_i} \cdot \frac{\partial V_i}{\partial V_o} = \frac{1}{V_i} \sum_r \left(v_{ir} \left(\frac{v_{or}}{v_{ir}} \cdot \frac{\partial v_{ir}}{\partial v_{or}} \right) \left(\frac{V_o}{v_{or}} \cdot \frac{\partial v_{or}}{\partial V_o} \right) \right)$$

1. S.J. Prais and H.S. Houthakker, op. cit., pp. 11-14.

Thus the aggregate elasticity for the i^{th} product will be the weighted sum of each of the r consumer's income-expenditure elasticities multiplied by that consumer's income elasticity with respect to total income. The weights being the expenditure of each consumer on the i^{th} product.

If it is assumed that when income changes occur, all incomes change by the same proportion, then the aggregate or market elasticity for the i^{th} product simplifies to the weighted average of the individual consumer's income-expenditure elasticities,

i.e. if all incomes change by the same proportions:

$$\frac{V_o}{v_{or}} \cdot \frac{\partial v_{or}}{\partial V_o} = 1 \quad \text{for all of the r consumers}$$

Thus
$$\frac{V_o}{V_i} \frac{\partial V_i}{\partial V_o} = \frac{1}{V_i} \sum_r v_{ir} \left(\frac{v_{or}}{v_{ir}} \frac{\partial v_{ir}}{\partial v_{or}} \right) \qquad \text{.....(1)}$$

If the single-log equation is used for estimating the relationship between income and expenditure on the i^{th} product, and it is assumed that a log-normal distribution of income occurs in the community, then the aggregate or market elasticity for the i^{th} product will be the elasticity calculated at the mean value of log V_o.[1] The aggregate or market elasticity may therefore be found in these terms for empirical estimation as follows:

With the stochastic estimating equation as:

$$V_i = a + b \log V_o$$

the first derivative is:

$$\frac{\partial V_i}{\partial V_o} = b \cdot \frac{1}{V_o}$$

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1. S.J. Prais and H.S. Houthakker, op. cit., p. 14.

The income-expenditure elasticity is:

$$\frac{\partial V_i}{\partial V_o} \cdot \frac{V_o}{V_i} = b \cdot \frac{1}{V_o} \cdot \frac{V_o}{V_i}$$

$$= {}^{b}/_{V_i}$$

But $V_i = a + b \log V_o$

Hence the elasticity is $\dfrac{b}{(a + b\log V_o)}$

If the mean value of $\log V_o = \log \bar{V}_o$

then the market elasticity = $\dfrac{b}{(a + b\log \bar{V}_o)}$ ......(2)

Equation 2 is thus the empirical estimate of equation 1 above, derived from the single-log equation estimate of the income-expenditure relationship.

Because the elasticities are calculated from an estimated equation, the coefficients of which have associated standard errors, it is desirable to be able to calculate the standard error of the elasticity. The method of evaluating the standard error used here was derived from the work of Turnovsky.[1]

Given an equation containing two constant terms a and b, Turnovsky shows that the elasticity derived from the equation (denoted as c) has a variance,

$$\text{var. } c = \left(\frac{\partial c}{\partial a}\right)^2 \text{ var. } a + \left(\frac{\partial c}{\partial b}\right)^2 \text{ var. } b + 2\left(\frac{\partial c}{\partial a}\frac{\partial c}{\partial b}\right) \text{ cov. } ab$$

Where c = the derived coefficient (elasticity)

1. S.J. Turnovsky, The New Zealand Automobile Market 1948-63: An Econometric Case Study of Disequilibrium, Technical Memorandum No. 7, New Zealand Institute of Economic Research, 1965, Unpublished mimeograph, p. 8.

a and b = parameters of the estimated equation.

The general form of the estimating equation used in this study was:

$$V_i = a + b \log V_o$$

putting $\log V_o = \overset{*}{V}$ to simplify the presentation the equation becomes:

$$V_i = a + b\overset{*}{V}$$

and thus $c = \dfrac{b}{a + b\overset{*}{V}}$

differentiating with respect to a

$$\frac{\partial c}{\partial a} = \frac{-b}{(a + b\overset{*}{V})^2}$$

differentiating with respect to b

$$\frac{\partial c}{\partial b} = \frac{a}{(a + b\overset{*}{V})^2}$$

It is also possible to express the variance of a and b, and covariance (a b) in terms of the variable variances and covariances. Estimation in these terms is much simpler.

Thus:

$$\text{var. } b = \frac{1}{n-2}\left[\frac{\text{var. } V_i}{\text{var. } \overset{*}{V}} - \left(\frac{\text{cov. } V_i\overset{*}{V}}{\text{var. } \overset{*}{V}}\right)^2\right]$$

$$\text{var. } a = \frac{(\overline{\overset{*}{V}^2})}{n(n-2)}\left[\frac{\text{var. } V_i}{\text{var. } \overset{*}{V}} - \left(\frac{\text{cov. } V_i\overset{*}{V}}{\text{var. } \overset{*}{V}}\right)^2\right]$$

$$\text{cov. } a\,b = \frac{-\overline{\overset{*}{V}}}{n-2}\left[\frac{\text{var. } V_i}{\text{var. } \overset{*}{V}} - \left(\frac{\text{cov. } V_i\overset{*}{V}}{\text{var. } \overset{*}{V}}\right)^2\right]$$

substituting for the terms in Turnovsky's estimating equation, and simplifying, gives:

$$\text{var. } c = \frac{1}{(n-2)\text{var. } \overset{*}{V}(a + b\overset{*}{V})^4} \cdot \frac{\text{var. } V_i - (\text{cov. } V_i\overset{*}{V})^2}{\text{var. } \overset{*}{V}} \cdot \left[a^2 + b^2(\text{var. } V_o + \overline{\overset{*}{V}}^2) + 2\,ab\,\overline{\overset{*}{V}}\right]$$

The standard error is equal to the square root of this expression.

Data Used in the Estimation of the Engel Curves.

Data for estimation of the Engel curves were derived from questions asked in the postal survey. Expenditure figures came directly from a budget question. This question asked respondents to list meat items purchased during the week in which they replied. Expenditure on all food was asked in a second question; a degree of error in answers to this question must be expected.

Disposable income was asked for in the form of eight income classes. Each class covered a £250 range of income, apart from the beginning and end classes which had larger ranges. Each household's income was taken at the midpoint of the range the respondent ticked, the midpoint value was then divided by the number of persons (or consumer units) in the household.

In taking the midpoint of each class, the implicit assumption is that the observations within each class are evenly distributed around the midpoint. This assumption will not be entirely accurate here because with some low income classes it may be expected that more respondents will have incomes in the upper portion of the £250 range. Equally with some high income classes the opposite can be expected. As no definite information was available on which to base a weighted distribution, the midpoint was chosen as the least unacceptable assumption.

All data were checked carefully to ensure accuracy. Very few observations, where all the required data were provided, were excluded. Where an observation was excluded, it was because reconciliation of data was definitely impossible (e.g. a meat expenditure greater than household income).

The Models Estimated.

Four models were estimated for each meat. The models were:

1. $V_i/C = a + b \log (V_o/C)$

where C = consumer units per household

V_o = disposable income per household

V_i = expenditure on each of i meat classes per household.

and a, b, and d = constants to be estimated.

2. $V_i/C = a + b \log(V_o/C) + d \operatorname{Log}C$

where d logC was an attempt to measure scale effects, other symbols are defined as for the first series.

3. $V_i/N = a + b \log(V_o/N)$ where N = number of people in the household, other symbols are defined as for the first series.

4. $V_i/N = a + b \log(V_o/N) + d \log N.$

where d logN was an attempt to measure scale effects, other symbols are as defined above.

Models three and four are thus a repetition of one and two, with data per person instead of per consumer unit. The four models correspond to the four alternative assumptions outlined earlier.

The meats for which each model was estimated were expenditure on: beef, lamb, mutton, pork, poultry, ham, bacon, non-carcase meat (i.e. sausages, etc.), all meat, non-meat food, and all food.

The Estimates.

All equations were estimated by ordinary least squares regression analysis. Table 3.1 shows the market elasticities derived from the equations of the first and third models. The equations themselves are shown in Appendix B. The levels of which the coefficients are significantly different from zero is shown by the code:

*** The coefficient significant at the one per cent level

** The coefficient significant at the five per cent level

* The coefficient significant at the ten per cent level.

No mark indicates that the coefficient was not significant at the ten per cent level.

The significance levels of the <u>regression</u> coefficients were calculated by t-test. In all equations where the regression coefficient was significantly different from zero at the ten per cent level or better, the coefficient of determination was similarly significant at the ten per cent level or better. The F-test as described by Weatherburn[1] was used for calculating the levels at which the coefficients of determination were significantly different from zero.

Levels at which the elasticities in Table 3.1 were significantly different from zero are shown above the elasticity, while the level at which the b-coefficients in the regression equations were significantly different from zero are shown alongside. The elasticity standard errors were estimated by the method outlined earlier,[2] and are shown below each elasticity. The significance of each elasticity was calculated by t-test.

The equations of models two and four, where the scale variable was included, resulted in the regression coefficients having lower levels of significance from zero. It was considered reasonable to reject these models on the grounds of possible bias in the estimates due to multicolinearity. The choice between models one and three was more

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1. C.E. Weatherburn, <u>A First Course in Mathematical Statistics</u>, Cambridge University Press, Cambridge, Second Edition, 1961, pp. 257-259.

2. Pp. 61-62.

TABLE 3.1

MARKET INCOME - EXPENDITURE ELASTICITIES.

	Per Consumer Unit Model		Per Person Model	
	Elasticity Per Consumer Unit	Significance of b-coefficient From Zero	Elasticity Per Person	Significance of b-coefficient From Zero
Beef	0.308	***	0.504*	***
	(0.211)		(0.296)	
Lamb	0.915	***	1.039	***
	(1.451)		(1.684)	
Mutton	-0.248	-	-0.112	-
	(0.368)		(0.257)	
Pork	0.076	-	0.211	-
	(0.489)		(0.579)	
Poultry	1.062	-	1.423	**
	(3.903)		(5.101)	
Ham	0.543	-	0.813	**
	(1.066)		(1.560)	
Bacon	0.161	-	0.324	-
	(0.306)		(0.429)	
Non-carcase Meat	0.741	***	0.755	***
	(0.864)		(0.933)	
All Meat	0.321***	***	0.517***	***
	(0.103)		(0.179)	
Non-meat Food	0.277**	***	0.381***	***
	(0.115)		(0.136)	
All Food	0.353***	***	0.427***	***
	(0.088)		(0.112)	

difficult to make. Model three was statistically the more acceptable, as the coefficients of determination were higher and the standard errors of the regression coefficients lower.
Acceptance of one model as being 'better' than another must, however, ultimately be made on the economic logic behind the structure of each model.

Because of a priori reasoning outlined earlier, it was decided that series three was the more acceptable. This model corresponded to the assumption that the budget and income coefficients of each age-sex group for each good are equal to unity. While it will be readily recognised that the meat requirements of each age-sex group are not the same, it was felt more realistic to apply the above weights, than to apply meat requirement weights to income. While a combination of consumer unit weights for meat expenditure, and equal weights for income could have resulted in 'better' explanation in a statistical sense, application of the results to policy would be more difficult, requiring the age-sex distribution of each New Zealand household to be known and used. These alternative models were therefore not estimated.

The interpretation of the elasticity standard errors requires some discussion. The results show that significance levels of the elasticities are in general lower than significance of the regression b-coefficients. In testing regression coefficients for significant differences from zero, the primary objective is to determine if there is a relationship between V_i and V_o. Having determined that the regression coefficient is significantly different from zero, it is useful to know if the elasticity is significantly different from zero or unity. This enables classification of the good into the luxury good, necessity, or inferior good categories. In Tables 3.1 and 3.2 the significance of the elasticities is shown as the significant difference from zero. The same calculations for significant difference from unity would, for example, show that the mutton elasticity is significantly different from unity. Thus the significance (or otherwise) of the elasticities must be considered in this light, rather than as a test for a non-zero relationship. The standard error of the elasticity therefore gives an estimate of the 'spread' or distribution of values the elasticity can take, given repeated sampling.

Interpreted in this way the results show that only limited confidence can be placed in the point estimate of the elasticities, as their distributions are quite wide. The mean values of the market elasticities are however *a priori* quite acceptable. Lamb, for example shows an income-expenditure elasticity of 1.039 at the geometric mean of income, a value similar to that expected. Unfortunately, however, the *elasticity* has such a wide distribution it is not significantly different from zero even at the ten per cent level.

For all equations the coefficients of determination were lower than expected. In other cross-section studies values between 0.6 and 0.8 are more usual for these coefficients.[1] Two points could be useful here. Firstly, the number of observations (125 and 114), while not as large as in some similar studies, were non the less high enough to make low coefficients of determination significantly different from zero at the accepted levels. Secondly, scatter diagrams of the observations show a wide variation in expenditure not correlated with income. The income-expenditure relationship is only a partial relationship, and hence a large unexplained variance need not be unexpected.

Table 3.2 presents the elasticities calculated from model three for different levels of income. The significance levels of each meat's regression coefficient (b-coefficient) is shown above the *meat* referred

1. See for example: S.J. Prais and H.S. Houthakker, op. cit., pp. 95-97.

TABLE 3.2

INCOME-EXPENDITURE ELASTICITIES - MODEL 3.*

	Elasticity at:-				Elasticity at:-			
	£100/hd. Per Year	£200/hd. Per Year	£300/hd. Per Year	Market Elasticity -Approx. £325/hd. Per Year	£400/hd. Per Year	£500/hd. Per Year	£600/hd. Per Year	"Initial Income" At Which $V_i = 0$
*** Beef	1.245	0.668	* 0.526	* 0.504	* 0.457	** 0.453	** 0.385	44.8
*** Lamb	-	2.175	1.134	1.039	0.855	0.718	0.635	124.3
Mutton	-0.099	-0.106	-0.111	-0.112	-0.115	-0.118	-0.120	
Pork	0.279	0.235	0.215	0.211	0.202	0.193	0.186	2.8
** Poultry	-	4.661	1.609	1.423	1.015	0.884	0.761	161.1
** Ham	19.571	1.343	0.870	0.813	0.695	0.602	0.543	95.1
Bacon	0.525	0.385	0.333	0.324	0.304	0.284	0.270	14.9
*** Non-carcase Meat	6.875	1.194	0.804	0.755	0.653	0.570	0.516	86.5
*** All Meat	1.328	** 0.691	*** 0.540	*** 0.517	*** 0.467	*** 0.423	*** 0.393	47.1
*** Non-meat Food	0.679	*** 0.462	*** 0.389	*** 0.381	*** 0.350	*** 0.324	*** 0.306	23.0
*** All Food	0.843	*** 0.532	*** 0.438	*** 0.427	*** 0.389	*** 0.358	*** 0.336	30.5

* Significance level of regression b-coefficients is shown above the meat name, while the significance level of the elasticities is shown above each elasticity.

to (i.e. on the left hand side). Significance levels of the elasticities are shown above the elasticities, but unlike Table 3.1 the elasticity standard errors are not given. Initial income levels are also presented in this table. In general, those meats which have higher elasticities at each income level also have a high initial income.

Beef, lamb, poultry, ham, non-carcase meat, all meat, non-meat food and all food regression coefficients were all significantly different from zero at the five per cent level or better. Of these, lamb and poultry were luxury meats at the geometric mean of income (approximately £325). Ham and non-carcase meat exhibited moderately high market income elasticities. The mutton coefficient, though not significantly different from zero in any of the four models, was in each case negative. It appears probable therefore that this meat is an 'inferior' good. The pork and bacon estimates were disappointing, these unsatisfactory estimates could in part due to the nature of the way the meat is used. Bacon is used in conjunction with many other foods, and hence a large reaction to income was unlikely. Pork appeared to be consumed mainly for a change in meat diet, and in this study there were few non-zero observations. Hence a non-zero relationship was unlikely to be determined.

The initial incomes estimated show the income per person per year necessary before consumption of each commodity would begin. An explanation of the elasticities and initial income levels for the 'composite' goods is necessary. These goods are all meat, non-meat food and all food. The initial income of £30 per person per year for food does, for example, not mean that up to that income no food would be purchased. This initial income indicates a mean figure for a composite basket of all foods, thus a unit of 'all food' would not be purchased until that income level was reached.

Initially it has been hoped to explore, in the second and fourth models, the effect of family size on expenditure for the goods for which Engel curves were calculated. Although most of the coefficients were not significant, the method is shown below with two of the significant results. It is suggested that little importance should be given to the empirical findings as they require further investigation. The theoretical aspects are, however, of interest in themselves. The results are drawn from equations of the fourth model.

Let V_i = expenditure per household on the i^{th} good

V_o = income per household

N = number of people in the household

The equations calculated were of the form:

$$V_i/_N = a + b \log(V_o/_N) + d \log N.$$

Thus $$\frac{\partial (V_i/_N)}{\partial N} = \frac{\partial (a)}{\partial N} + \frac{\partial}{\partial N} (b \log(V_o/_N)) + \frac{\partial}{\partial N} (d \log N)$$

$$= \frac{d - b}{N}$$

The partial derivative above is a measure of the change in expenditure per person on the i^{th} good as household size increases, other factors (i.e. income per household) held constant. An alternative expression will shortly be presented which expresses the scale effects with income per person held constant. This latter method is a more accurate definition of scale effects, but does not express the more usual occurrence in the real world, i.e. a person on a fixed income increasing the number of his dependents. Both methods of expressing the results have distinct uses.

For the first derivative, $\left[\frac{d - b}{N}\right]$, where N = 2 the change in expenditure as household size increases from 1 to 2 persons is shown.

Where N = 3, the change from 2 to 3 persons is shown. Table 3.3 shows the estimated change in expenditure per person per week, income per household held constant. The unit of currency is the shilling. It will be noted that the estimated change decreases as the base size of the household increases. This might be expected because proportionate change in household size becomes smaller, and hence the decline in per person income becomes smaller. Income and scale effects on expenditure will therefore decline in absolute value. The results shown are for meat groups which had scale coefficients significant at the ten per cent level or better.

TABLE 3.3

CHANGE IN PER PERSON EXPENDITURE, IN SHILLINGS EXPENDITURE PER WEEK, INCOME PER HOUSEHOLD CONSTANT.

	Change From:-				
Meat	1 - 2 Persons	2 - 3 Persons	3 - 4 Persons	4 - 5 Persons	5 - 6 Persons
Beef	-1.325	-0.883	-0.663	-0.530	-0.442
All meat	-3.765	-2.510	-1.882	-1.506	-1.255

The results indicate that as the household size increases from one to two persons, 1.325 shillings per person per week less would be spent on beef. Similarly from one to six persons 3.843 shillings per person per week less would be spent on beef.[1] It must be recognised that these figures do not represent only scale effects, (i.e. more efficient use of meat) but also include the decreased per person expenditure due to purchase of cheaper cuts and/or substitutes because of the decline in per person income.

1. 3.843 shillings per person per week, represents the sum of the individual effects from one to two, two to three, etc.

An alternative formulation is to estimate the pure scale effects, that is with <u>income per person</u> held constant, (i.e. with $V_{o/N}$ in the above equation held constant). The partial derivative is then, $\frac{d}{V_n}$

TABLE 3.4

CHANGE IN PER PERSON EXPENDITURE, IN SHILLINGS EXPENDITURE PER WEEK, INCOME PER PERSON CONSTANT.

	Change From:-				
Meat	1 - 2 Persons	2 - 3 Persons	3 - 4 Persons	4 - 5 Persons	5 - 6 Persons
Beef	-0.560	-0.373	-0.280	-0.224	-0.187
All meat	-2.145	-1.429	-1.072	-0.857	-0.715

The results shown in Table 3.4 indicate that pure scale effects could be of significant magnitude, when compared with mean levels of expenditure shown in Table 2.6.[1] The difference between Tables 3.3 and 3.4 indicates the change in expenditure due to substitution of cheaper meat cuts, and reduced quantity of meat purchased of the specified meat type, when income per person declines because the number of persons in a household with fixed income rises. With beef the income effect is indicated as being of greater magnitude than the scale effect. Table 3.4 therefore gives an estimate of pure scale effect *ceteris paribus*, while Table 3.3 shows the overall effect on expenditure when the number of people in a household with fixed income increases.

1. When comparing the scale effects with the mean expenditures shown in Table 2.6, it must be remembered that the mean expenditures were calculated over the whole sample, and will thus be at the mean household size; in this sample 3.7 persons per household.

<u>Discussion</u>

This chapter has presented and discussed the research method and results of Engel curve estimation for several meats. Data used in this estimation were derived from the postal survey of Christchurch consumers outlined in Chapter 2. At the conclusion of Chapter 2, some limitations upon the usefulness of these data were discussed. That discussion will not be repeated here, although the points made in Chapter 2 are equally applicable to Chapter 3.

The first section of this chapter considered the theoretical requirements of income-expenditure and income-consumption relationships. There are several weaknesses in the application of this theory to the empirical problem discussed. Generalising from the single consumer to the community is by far the most serious of these difficulties. In estimating the community's Engel curve for a good, it may therefore be expected that a large unexplained variation between individual observations will occur. This did occur, and resulted in low values for the coefficients of determination. These values were lower than in other studies of this type. There is therefore a wide variation in expenditure patterns between households not correlated with income. Influences which caused this variation include many diverse and usually non quantifiable factors, (e.g. occupation, religion, and tastes, etc.). While these are usually summer up in the term 'preferences', it is evident that individual consumers' preference schedules may bear little or no resemblance to one another.

Appropriate mathematical functions to fit to the data are anothe need. At present no single mathematical function is suitable for universal application. The choice of a function is thus always difficult because the researcher must choose in a 'second-best' rather than optimal situation. The function chosen will always have a large influence on the pattern of results, hence the choice of the functional form is of the greatest importance. As a general rule, it appears that the single log function is the most appropriate for foods, and the double log for other items, but this is by no means proven.

The statistical problem of obtaining confidence limits for elasticities derived from the single log equation is not very great. However, it appears that the use of two coefficients to derive the elasticity, each of which has a distribution of its own, inevitably leads to a wide distribution of values the elasticity can take. The reduced confidence that can be placed in the estimated values of these elasticities does restrict their application.

The results achieved from the study are therefore of mixed value. The aggregate items (all meat, non-meat food, and all food) were the best. High equation coefficient and elasticity significance levels were achieved, with moderate (but highly significant) values for the coefficients of determination. For the individual meats, results were disappointing concerning elasticity significance levels and the size of the coefficients of determination. It appears that the greater the breakdown of data into smaller subgroups, the greater the variation in expenditure patterns not correlated with income.

There are several important policy conclusions which can be drawn from the results of Chapters 2 and 3. A few of these will now be considered, concentrating on the policy conclusions with respect to pigmeats. The evidence presented here indicates that pigmeats are not favoured by consumers, even though pork was ranked third in preference. Pigmeats were considered too expensive for everyday eating (with the exception of bacon), and pork was wrongly thought to be higher priced than poultry. Pigmeat consumption in New Zealand is proportionately much lower than in other countries. With a reasonably high preference for pork, but low actual consumption (and expenditure), it becomes evident that the price attitude of consumers is a large factor in depressing demand for pork. Average expenditure per person per week on <u>all</u> pigmeats was lower than for beef, lamb, or mutton.

If a successful transformation of the pigmeat industry to grain feeding is to be achieved, a higher volume market will need to be sought. At present a large export market for New Zealand pigmeats is unlikely as the local wholesale price is above world price. Hence a higher volume market will be required within New Zealand. This means that the share of the New Zealand meat market held by pigmeats will need to be increased. The view held by most consumers that pork is a luxury meat will need to be 'corrected'. A strong case can be made for pork over beef and lamb if prices are compared on a quality for quality basis. It would seem that a <u>constructive</u> promotional campaign on the part of the New Zealand Pig Producers' Council, and the marketing industry, aimed at informing the consumer of the price, relative cost, and uses of pigmeats (especially pork), would greatly benefit the industry.

Ham, especially cooked, sliced ham, is certainly highly priced. Holding or reducing the price will require the industry to look critically at processing methods, costs, and optimum size of processing plant. Bacon, while still competitive with its substitutes, would be put in a more advantageous position if its relative price could be lowered. Both bacon and ham are processed by the same operators.

Pigmeat smallgoods are one of the few well advertised meat items in New Zealand. However, this advertising mostly takes the form of 'brand' promotion. From other investigation separate from the survey, it appears that consumers are not brand conscious in buying smallgoods, in spite of many years of advertising. It is suggested here that promotion expenditure would yield greater results if diverted into promotion as outlined above, and to increasing the variety of small-goods available and informing the public accordingly.

The estimated income-expenditure elasticities show that lamb and poultry are luxury meats at the mean level of income. Porportional increases in expenditure on these meats will rise faster than proportional increase in income. There seems therefore to be good prospects for the meat-chicken industry in New Zealand, given a continuous upward movement of incomes. Ham and non-carcase meats (processed small-goods etc.,), have moderately high income effects. Beef, the major meat purchase, can expect its share of the consumer's pound to decline as income rises. Pork and bacon results were not significant. The cause of the non-significance could be of importance. For pork there were very few purchases shown for the weekly budget, hence it is unlikely that this figure is accurate. Bacon is used in smaller quantities with a meal than other meats, thus it is possible that income effects will not be large, and more likely to be outweighed by personal preferences.

The mutton elasticity is also not significantly different from zero, but interpreted in conjunction with answers to specific questions in the questionnaire, it could well be negative, indicating mutton is considered an inferior meat. If this is so, it indicates that price is important to the consumer, because expenditure on mutton is second only to beef.

These are not the only policy conclusions which can be drawn from the survey results. Other conclusions will be made and used in the specification of the time-series models, and in the final discussion of this work. The remaining chapters will be concerned with the specification and estimation of the New Zealand meat market time-series models.

APPENDIX B

THE ESTIMATED ENGEL CURVES.

Note: The level at which regression coefficients, and coefficients of determination are significantly different from zero is shown by the code discussed in Chapter 3, pp. 64-65.

Model One

Dependent Variable (V_i) Expenditure on each food in shillings per Consumer Unit per week.

Independent Variable (V_o) Logarithm of Disposable Income in Pounds per Consumer Unit per year.

Dependent Variable (V_i)	Constant	Coefficient of Independent Variable (V_o)	r^2	Number of Observations
(1)	(2)	(3)	(4)	(5)
Beef	-4.625	1.614*** (0.607)	0.054***	125
Lamb	-8.592	1.779*** (0.702)	0.050***	125
Mutton	5.771	-0.580 (0.591)	0.008	125
Pork	0.396	0.055 (0.336)	0.0002	125
Poultry	-2.306	0.463 (0.368)	0.013	125
Ham	-0.824	0.202 (0.158)	0.013	125
Bacon	0.035	0.132 (0.206)	0.003	125
Non-Carcase Meat	-3.943	0.862*** (0.304)	0.062***	125
All Meat	-12.062	4.262*** (0.643)	0.198***	180
Non-Meat Food	-18.003	7.841*** (2.102)	0.110***	114
All Food	-2.221	0.723*** (0.070)	0.291***	262

Model Two

Variables: As for Model One, apart from the inclusion of a second independent variable, log (Number of Consumer Units).

	Independent Variables				
Dependent Variable (V_i)	Constant	Coefficient of Income (V_o)	Coefficient of No. Consumer Units (N)	R^2	Number of Observations
(1)	(2)	(3)	(4)	(5)	(6)
Beef	-1.127	1.200* (0.681)	-0.896 (0.677)	0.068	125
Lamb	-1.294	0.915 (0.775)	-1.871 (0.770)	0.094	125
Mutton	3.836	-0.351 (0.666)	0.496 (0.661)	0.012	125
Pork	1.574	-0.085 (0.378)	-0.302 (0.376)	0.005	125
Poultry	0.109	0.177 (0.412)	-0.619 (0.409)	0.031	125
Ham	-1.055	0.229 (0.179)	0.059 (0.178)	0.014	125
Bacon	1.243	-0.012 (0.231)	-0.310 (0.229)	0.018	125
Non-Carcase Meat	-1.926	0.623* (0.340)	-0.517 (0.338)	0.079***	125
All Meat	1.355	2.697*** (0.942)	-3.959*** (0.935)	0.279***	125
Non-Meat Food	-14.846	7.474*** (2.381)	-0.831 (2.496)	0.111***	114
All Food	-0.650	0.510*** (0.124)	-0.263** (0.130)	0.248***	114

Model Three

Dependent Variable (V_i) Expenditure on each food in shillings per person per week.

Independent Variable (V_o) Logarithm of Disposable Income in Pounds per person per year.

Dependent Variable (V_i) (1)	Constant (2)	Coefficient of Independent Variable (V_o) (3)	r^2 (4)	Number of Observations (5)
Beef	-8.395	2.208*** (0.480)	0.147***	125
Lamb	-8.969	1.860*** (0.572)	0.079***	125
Mutton	3.322	-0.266 (0.452)	0.002	125
Pork	-0.139	0.133 (0.252)	0.002	125
Poultry	-3.009	0.592*** (0.296)	0.031**	125
Ham	-1.248	0.274** (0.126)	0.037**	125
Bacon	-0.627	0.232 (0.161)	0.016	125
Non-Carcase Meat	-3.434	0.770*** (0.245)	0.074***	125
All meat	-22.499	5.841*** (0.733)	0.340***	125
Non-Meat Food	-29.543	9.429*** (1.636)	0.229***	114
All Food	-52.499	15.355*** (1.695)	0.400***	114

Model Four

Variables: As for Model Three, apart from the inclusion of a second independent variable, log (Number of Persons per Household).

Dependent Variable (V_i)	Constant	Independent Variables: Coefficient of Income (V_o)	Coefficient of Number of Persons (N)	R^2	Number of Observations
(1)	(2)	(3)	(4)	(5)	(6)
Beef	-3.009	1.529** (0.595)	-1.120* (0.593)	0.171***	125
Lamb	-0.147	0.748 (0.702)	-1.835*** (0.699)	0.128***	125
Mutton	2.576	-0.132 (0.569)	0.155 (0.566)	0.003	125
Pork	0.865	0.006 (0.316)	-0.209 (0.315)	0.005	125
Poultry	-0.317	0.252 (0.369)	-0.560 (0.368)	0.050**	125
Ham	-1.361	0.288* (0.159)	0.024 (0.158)	0.037	125
Bacon	0.897	0.040 (0.201)	-0.317 (0.201)	0.036	125
Non-Carcase Meat	-1.387	0.512* (0.306)	-0.426 (0.305)	0.089***	125
All Meat	-1.886	3.242*** (0.837)	-4.287*** (0.834)	0.458***	125
Non-Meat Food	-18.113	8.021*** (2.036)	-2.482 (2.141)	0.238***	114
All Food	-72.930	15.355*** (1.784)	6.819 (267.818)	0.400***	114

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