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# A STUDY OF THE DEMAND FOR BUTTER IN THE UNITED KINGDOM

WILFRED CANDLER  
ROBERT TOWNSLEY

*Massey College, New Zealand*

Statistical estimation of the demand function for most industrial, and many agricultural, products is inhibited by price fixing or price stabilizing arrangements which prevent observation of the full range of possible price-quantity combinations. In the period 1956 to 1961 the London butter market has illustrated how markedly price can fluctuate, when not subject to a stabilizing agreement. In the period 1958 to 1961 estimates of retail sales of butter are available, and these permit the estimation of the demand for butter at retail. The time lag between production and consumption decisions means that there is no problem of identification. The present study uses weekly price and quantity information, and there is a serious problem of auto-correlation of the observations.

The interesting story of the development of the London butter market in Tooley Street has been ignored. Rather, this study provides a brief description of the current working of the butter market, together with new estimates for the demand function for butter in the United Kingdom. Previous estimates of the United Kingdom price elasticity of demand for butter have been published by Brown<sup>1,2</sup> as  $-.6$ , in 1954-58, by Stone<sup>3</sup> as  $-.37$  in 1921-38 and anonymously in *Economic Trends*<sup>4</sup> as  $-.34$ . In this study the elasticity is estimated as  $-.46$  when retail price exceeds 2/6 lb., and as  $-1.4$  at 2/6 to 2/2 lb.

## *Brief Description of the Market*

In the London butter market a few national butter marketing agencies face a relatively large number of wholesale merchants. The vendors set the price for their butter and the merchants decide the quantity they will take at the price quoted.<sup>5</sup> The price for any grade of butter can be changed at any time but generally the prices set on Monday rule for the rest of the week. Figure 1 gives the wholesale price for New Zealand, Danish, and other butter for the post-war period of free prices. From this figure, it is evident that while all butter prices follow the same general pattern, at the same time substantial differences in the margins between the prices of butter from different origins can develop. In particular the Danish authorities tend to hold their price until they

1. J. A. C. Brown, "The Demand for Butter, Margarine and Cooking Fats in the United Kingdom, 1954-1958." F.A.O. Background Paper, Rome, 26th August, 1958, pp. 10, mimeo.

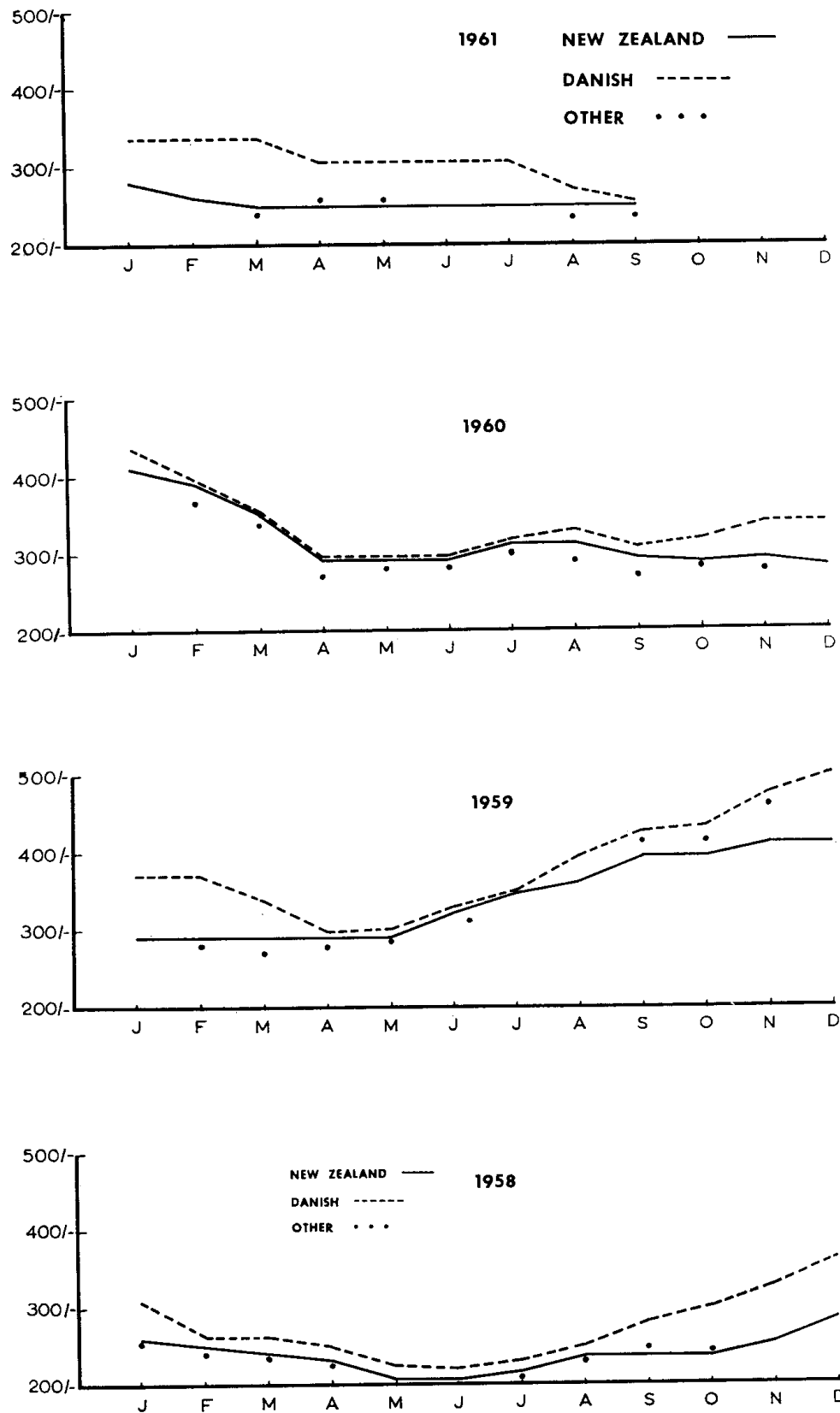
2. J. A. C. Brown, "Seasonality of Demand for Food in the United Kingdom Since Derationing," *Journal of Agricultural Economics*, Vol. 13 (1959), pp. 228-249.

3. Richard Stone, *The Measurement of Consumers' Expenditure and Behaviour in the United Kingdom 1920-1938*, Vol. 1. Cambridge University Press, 1954.

4. Anonymous, *Economic Trends* No. 98, December, 1961.

5. Sometimes the New Zealand price is set below its equilibrium value. In this case the selling authorities ration merchants on the basis of previous purchases of New Zealand butter. This is to prevent major speculative purchases when the price seems likely to rise, or during periods of general shortage in an attempt to hold New Zealand butter price down to a "fair" level.

FIGURE 1



are forced into a series of spectacular price cuts. The New Zealand authorities, on the other hand, tend to prefer a more graceful, if less spectacular, price decline. Which policy is most profitable depends, of course, on the cross-elasticities of demand.

Figure 1 also illustrates the general pattern of prices; usually, the Danish price is greater than or equal to the New Zealand price which is usually greater than or equal to the price of butter from other origins. The price of Australian butter has not been shown separately, since it is always offered at a discount of from one to three shillings per hundredweight, on the New Zealand price. The authors have not found an authoritative reference which would enable them to say whether New Zealand acts as a price leader with Australia accepting her lead, or whether the Australian and New Zealand selling authorities set the price after consultation.

A noticeable feature of Figure 1 is the way in which the New Zealand authorities have gone from a policy of continually varying prices to a policy of keeping prices constant for long periods.

A point hinted at in Figure 1, is that there are essentially four butter markets:

1. A market for Danish butter,
2. A market for New Zealand butter,
3. A market for blending butter, and
4. A market for butter used in manufacturing and the catering trade.

Danish butter is a lactic butter with a different taste and appearance to New Zealand's non-lactic butter. There is a distinct demand for both Danish and New Zealand butters at retail. (New Zealand spends about £400,000 per year on advertising to promote the demand for *New Zealand* butter and cheese.) There is also a demand for branded butters, such as Daisy brand, which are a blend of the cheaper types of butter. Finally, there is a demand for butter to be used commercially for cooking purposes.<sup>6</sup>

### *Wholesale Analysis*

An econometric analysis almost always resembles an iceberg in the sense that the part that can be seen (or is worth looking at) is much smaller than the part that remains unseen. Only a small portion of the calculations carried out for the Wholesale market are reported here, and even these should possibly be submerged. They are included because of their qualitative rather than their quantitative significance.

*Demand (Quantity) Relation:* A moderately successful equation for the *wholesale demand for New Zealand butter* in the period August 1955 to August 1956 was calculated as

$$(1) \quad Y = 517 + 596X_1 + 192X_2 - .872X_3; R^2 = .66, d = 1.48 N = 52$$

(75)            (77)    (.415)

Where  $Y$  is quantity demanded in tens of tons per week.

$X_1$  is speculative purchases when prices begin to rise,

$X_2$  is speculative purchases the week after the price rise, and

$X_3$  is the price of New Zealand butter in shillings per hundredweight.

Equation (1) estimates that in the period August 1955 to August 1956 an increase in the wholesale price of New Zealand butter by

6. Unfortunately the existence of these distinct markets cannot be properly documented since, unaccountably, the necessary information on retail sales does not appear to have been collected.

1/- cwt. decreased the quantity demanded per week by 8 ton 14 cwt.

Figure 2b illustrates the explanation afforded by equation (1) for the period for which it was calculated. Figure 2a gives the wholesale price for butter over the same period. Figure 3b illustrates the prediction of butter purchases in 1956/57 based on equation (1) (i.e. based on the information obtained in 1955-56). That is, Figure 3b is "pure prediction". Fig. 3a gives the wholesale price for butter in 1956/57.

A coefficient of multiple determination ( $R^2$ ) of .66 from 52 observations is statistically highly significant. It is not, however, in the authors' opinion high enough to be useful, especially when the bulk of the explanation is in fact provided by two major speculative purchases.

Autocorrelation of the errors in equation (1) was tested by calculating the 'd' statistic<sup>7</sup>. The value obtained ( $d = 1.48$ ,  $N = 52$ ) was used to test for positive autocorrelation of the errors; the test being inconclusive at the 5% level of significance.

The significance of the correlation between the quantity of New Zealand butter demanded ( $Y$ ) and the price of New Zealand butter ( $X_3$ ), was tested by calculating the effective degrees of freedom.<sup>8</sup> The effective degrees of freedom ( $n'$ ) was calculated to equal 23 ( $N = 52$ ).

In Figure 2b, it is easy to see that most of the variation in quantity demanded is due to the large purchases in the two starred (\*) periods. Figure 2a, shows that these purchases correspond to a rise in the price for butter; they are purely speculative purchases. The importance of these speculative purchases in explaining quantity purchased is illustrated in the Analysis of Variance, in Table 1. In this analysis  $X_1$ , is given credit for all the variation associated with it.  $X_2$  is given credit for the variation due to  $X_2$  which has not previously been explained by  $X_1$ , and  $X_3$  is given credit for explanation, not already provided by  $X_1$  and  $X_2$ .

TABLE 1.  
*Analysis of Variance of Weekly Wholesale Sales of Butter;  
August 1955 to August 1956*

Source of Variation	d.f.	S.S.	M.S.	F
Speculative Purchase $X_1$	1	792,498	792,498	76
Extra explained by $X_2$	1	78,046	78,046	7.49
Extra explained by $X_3$	1	45,893	45,893	4.41
Unexplained .. .. .	48	500,002	10,416	
Total .. .. .	51	1,416,439		

7. J. Durbin and G. S. Watson, "Testing For Serial Correlation in Least Squares Regression", *Biometrika*, Vol. 38, 1951, pp. 159 ff.

8. G. H. Orcutt and S. F. James, "Testing the Significance of Correlations Between Time Series", *Biometrika*, Vol. 35, (1948), pp. 397 ff.

FIGURE 2A

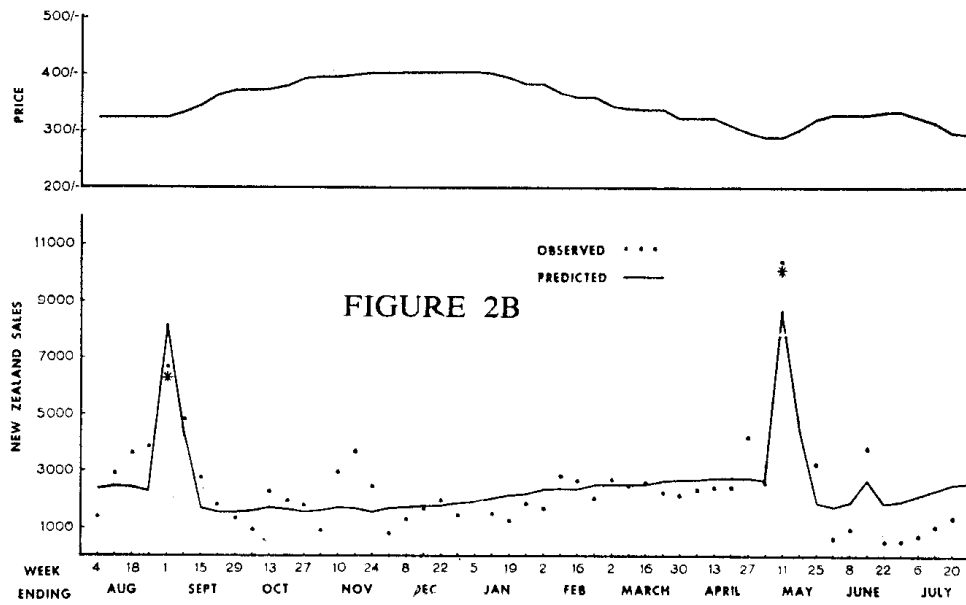
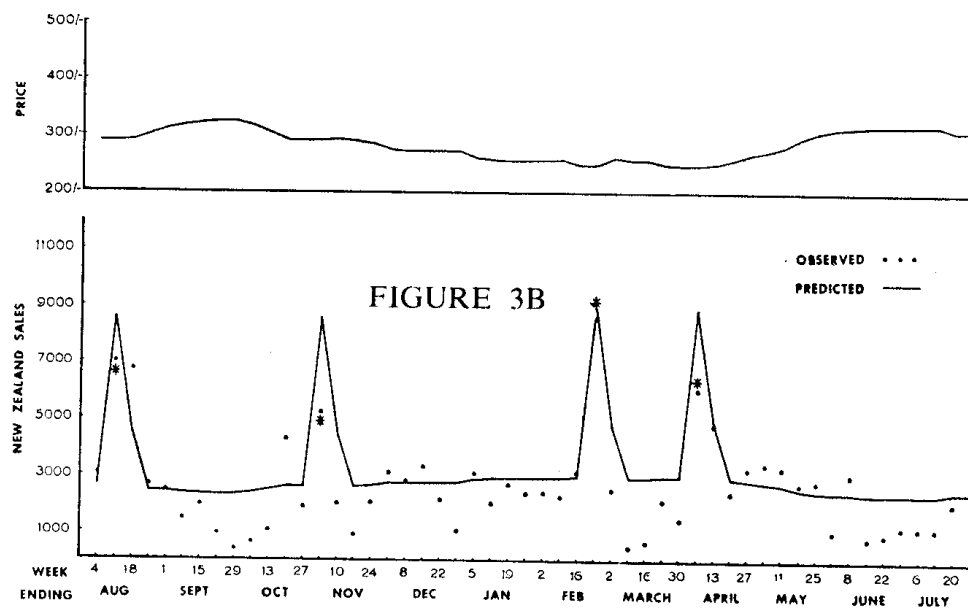


FIGURE 3A



A careful examination of Figures 2a and 2b reveals that the second speculative purchase commenced *in the last week of low prices*, whereas the first speculative purchase commenced in the first week after prices were raised.<sup>9</sup> It is probable that the magnitude of such speculative purchases explains the change from continually varying prices to long periods with constant prices.<sup>10</sup> Steps are now taken to prevent merchants buying quantities grossly out of line with their previous purchases. This prevents the really blatant cases of speculation.

Suprisingly enough the analysis of variance in Table 1 shows that the change from a falling to an increasing price has much more effect on the quantity demanded, than the absolute level of prices. A slightly better fit (a slightly higher  $R^2$ ) can be obtained by including in the equation some estimate of the likely level of merchants stocks. In the authors' opinion the statistical difficulties which enter when this model is used are greater than the extra explanation warrants.

The really discouraging feature of equation (1) is that when the deviations from regression (i.e. the "unexplained" variations in the quantity demanded) are plotted against other plausible explanatory variables, no systematic effects can be seen. In Figure 4, these "unexplained" purchases of New Zealand butter have been plotted against the Danish price, the differences between Danish and New Zealand price, and the ratio of Danish to New Zealand price. It would appear that during this period there was little relationship between the price of Danish butter and the demand for New Zealand butter. These scatter diagrams suggest that the cross-elasticity of demand between New Zealand butter and Danish prices is low. This supports the earlier assertion that there is "a separate market" for Danish and New Zealand butter.

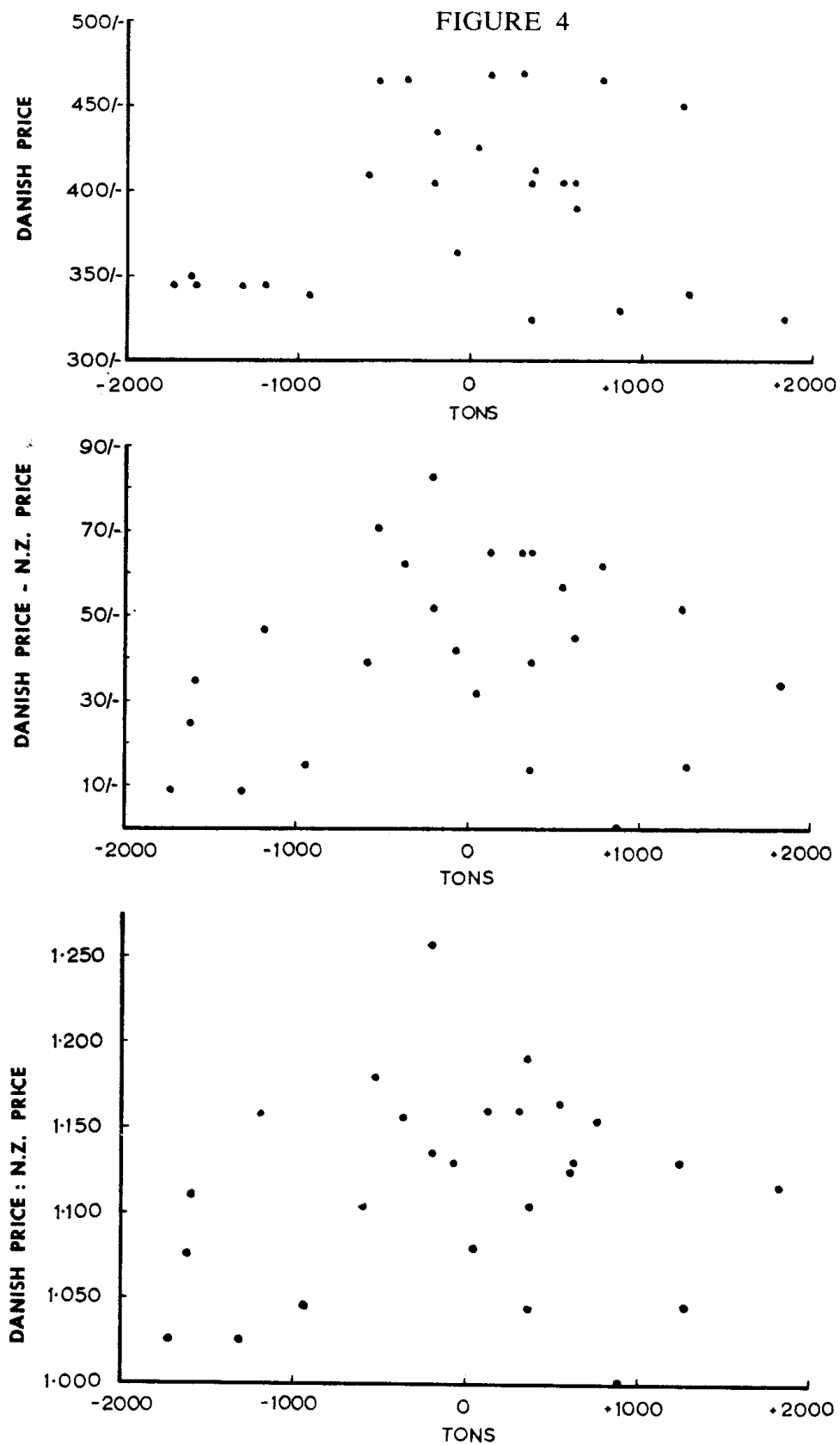
*Supply (Price) Relation:* A fairly simple empirical relationship holds, in some years, between the price for New Zealand butter and

TABLE 2.  
*Relation Between United Kingdom Cold Store Stocks of Butter and the Wholesale Price for New Zealand Butter*

Period	Constant (a)	Regression Coefficient (b)	Standard Error of b	Coefficient of Determination
1955-56	418	— .20	.02	.81
1956-57	299	— .02	.04	.01
1957-58	357	— .20	.03	.56
1958-59	385	— .24	.08	.27
1959-60	457	— .31	.02	.92
1955-60	390	— .19	.07	.50

9. Or inspection of page 81 of the Ninth Annual Report of the Dairy Products Marketing Commission, Wellington, 1956.

10. It is interesting to note that if equation (1) was an entirely satisfactory description of the market, the correct price policy would be to raise and lower prices on alternate weeks, since this would lead to "speculative purchases" every other week! The authors do not believe equation (1) would describe the effects of such a pricing policy adequately.



"UNEXPLAINED" PURCHASES OF NEW ZEALAND BUTTER



the level of cold-store stocks of butter in the United Kingdom. Equations have been derived for individual years and for the total period 1955 to 1960. The equations, summarised in Table 2, are of the form:

$$Y = a + bX$$

where  $Y$  is the price in shillings per hundredweight and

$X$  is the United Kingdom cold store stocks in hundreds of tons.

It is clear that the relationship has not held uniformly over the entire period, but in 1959-60 the fit is fairly good.

It should be emphasised that while the results in Table 2 are of some interest as suggesting one way in which (consciously or unconsciously) the price of butter is determined, they are of little real operational use, since they do not explain *why* the cold store stocks are at a given level. To predict the level of cold store stocks it is necessary to be able to predict the level of consumption.

#### *Wholesale and Retail Prices*

The influence of the wholesale price of butter on the retail price is direct and immediate. This is illustrated by:

$$(2) Y = 1.19 + .12 X ; r^2 = .99$$

where  $Y$  is the retail price in pence per lb., for New Zealand butter in "Multiple" stores, and  $X$  is the wholesale price of the butter in the previous week in shillings per hundredweight.

This relationship was calculated from weekly figures, for the period January, 1958 to April, 1961.

Converting  $X$  to  $X'$ , the wholesale price in pence per pound, for the previous week we have:

$$(2a) Y = 1.19 + 1.12X' , r^2 = .99$$

From this equation it can be estimated that the marketing margin between wholesale and retail is 4.3d. when butter is 2/2 lb. at retail and 6.6d. when it is 4/2 lb.

The most important point about equation (2) is that it shows the close relationship between retail and wholesale prices. *This means that in setting the wholesale price for New Zealand butter the New Zealand Dairy Board is setting the retail price for the following week.*

#### *Demand at Retail*

Since April 1959 the Commonwealth Economic Committee has published a weekly "index of retail sales" of butter.<sup>11</sup> This index has a base of 100 for retail sales in the four weeks ending 12th October 1957. When the total sales according to the index are divided into the total wholesale sales for the period January 1958 to December 1960, it would appear that the index of 100 corresponds to weekly sales of

11. The C.E.C. "index of retail sales" of butter is published in the C.E.C. Intelligence Bulletin. It has been published regularly from April 1959 to date. Some of the larger co-operative societies and multiple stores co-operate in furnishing regularly to the C.E.C. details of their weekly retail butter sales. An index is constructed from these figures relating to the average of the 4 weeks ended 12th October, 1957 as base (=100). This index does not profess to show total butter sales in the United Kingdom as it refers to sales of a limited number of firms. Moreover, the index does not take into account any changes in the proportion of the total trade done by the co-operatives and multiples who provide the basic data for the index. At the same time the index provides the only available indicator of total retail sales of butter.

about 7,400 tons.<sup>12</sup> The index of weekly sales has been graphed against the price of butter in Figure 5. The reader is reminded that as is usual in economics price appears on the vertical axis even though the direction of causation is clearly from price to quantity.

In Figure 5 the price for *New Zealand* butter is graphed against the C.E.C. index of *total* retail sales of all types of butter. Three fairly distinct periods can be seen:

*Period I:* 12th January, 1958 to 1st June, 1958. Low and falling prices with rapidly increasing sales,

*Period II:* 8th June, 1958 to 1st November, 1959. Increasing prices with a slow decline in sales, and,

*Period III:* 21st November, 1959 to 20th March, 1961. Declining prices and a slow increase in sales.

Two main conclusions suggest themselves from an inspection of Figure 5:

1. The elasticity of demand appears to be much greater at 2/- to 2/6 lb. than at higher prices.

2. Demand would appear to exhibit a hysteresis effect by which the quantity consumed at a given price is greater if prices are rising than if they are falling. This would suggest that butter consumers are rather slow to change their consumption patterns. As prices rise they continue to eat butter for some time after they can really "afford" it, and as prices decline they continue to eat margarine even after they could "afford" butter. Alternatively the hysteresis effect could be due to the apparent downward bias of the consumption index mentioned in footnote 12.

TABLE 3.  
*Regression Estimates of United Kingdom Retail Demand for Butter*

Function: $Y = a + bX$ (Linear)					
Period	$a$	$b$	$s_b$	$r^2$	$d$
I	306	-6.24	$\pm .72$	.98	1.10
II	169	-1.38	$\pm .06$	.88	0.28
III	152	-1.19	$\pm 1.19$	.90	1.20

Function: $Y = aX^b$ (Constant Elasticity)					
Period	$a$	$b$	$s_b$	$r^2$	$d$
I	14,160	-1.41	$\pm .08$	.95	.62
II	568	-.44	$\pm .02$	.90	.33
III	607	-.48	$\pm .02$	.91	.93

12. When the period is split into the years, 1958, 1959 and 1960, an index of 100 for each of these years corresponds to 6,900, 7,600, and 7,700 tons per week respectively. This suggests that there may have been a downward bias of the index with time.

FIGURE 5

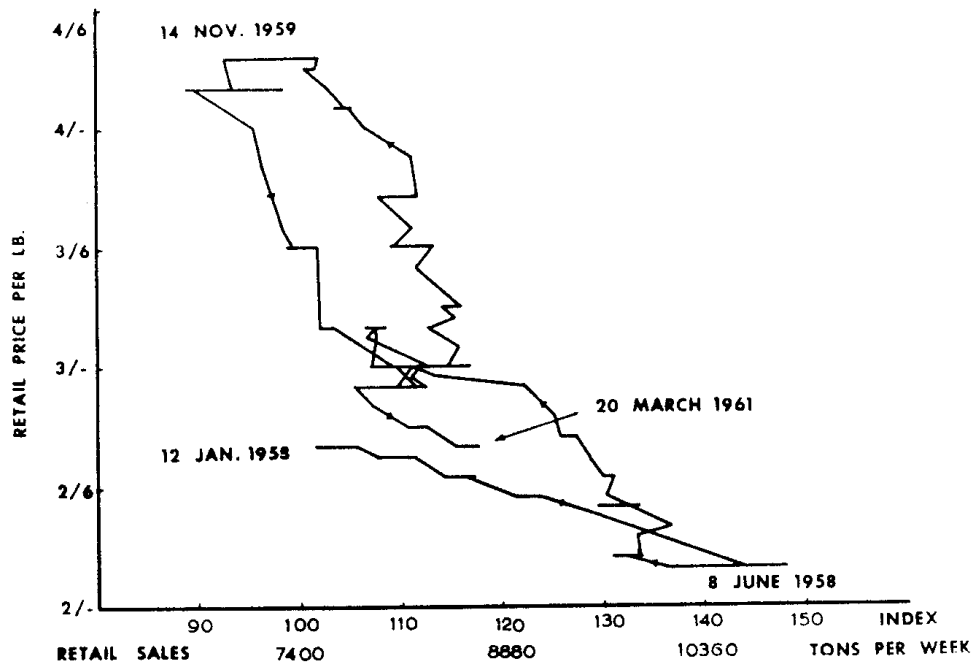
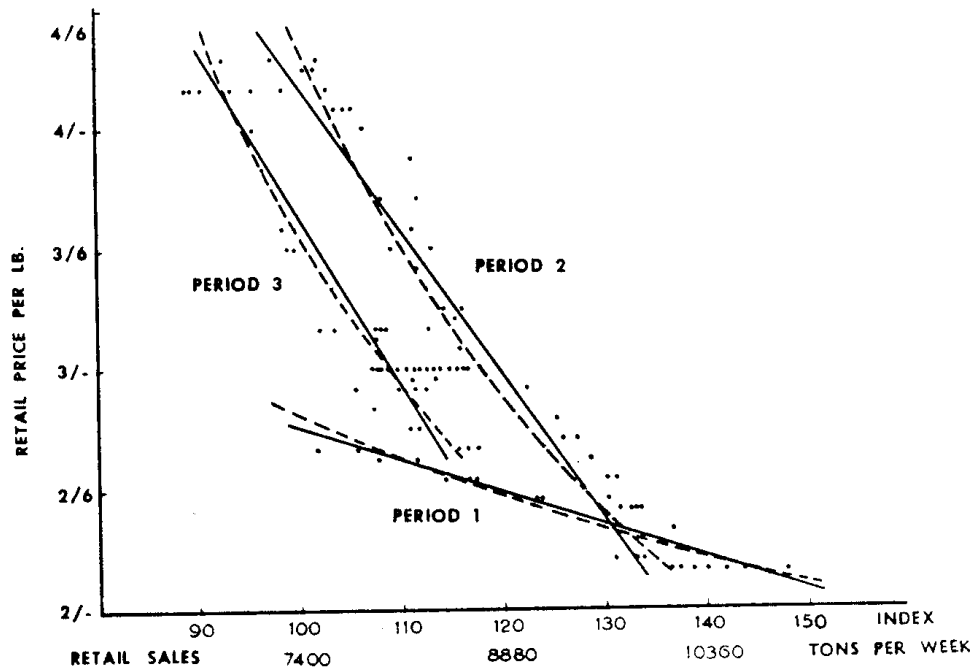


FIGURE 6



Linear and constant elasticity demand functions <sup>13,14</sup> have been fitted to the three periods. The numerical results appear in Table 3, and the general fit of the regression lines can be seen in Figure 6. In both equations  $Y$  is the C.E.C. index of quantity consumed and  $X$  is the price in pence per lb. Since an index of 100 has been estimated as being approximately 7,400 tons per week, multiplication of the coefficients in Table 3 by 74 gives a prediction of butter consumed in tons per week.

The difference in the slope (or elasticity) of the functions in Period I and in the other two periods strikingly confirms the feeling that the demand in the first period is more elastic than in the later period.

### *Retail Expenditure on Butter*

Expenditure is price times quantity hence we can express the consumers expenditure on butter:

$$E = XY \text{ or } E = aX + bX^2$$

for the linear function. Differentiating with respect to  $X$  and setting

13. The constant elasticity demand function is  $Q = aP^b$  where  $Q$  is quantity and  $P$  is price. As is well known the elasticity is constant and equal to  $b$ .

14. The set of alternative functions that could perhaps have been used is very great. With weekly data of the nature reported in this article, the use of lagged values of quantity consumed, as in the function:—

$$Y_t = a + bP_t + cY_{t-1}$$

is hard to justify, in spite of the well known consequences of ignoring time lags. The extremely high positive correlation between  $Y_t$  and  $Y_{t-1}$ , within periods, would lead to unstable and meaningless regression coefficients.

It would also seem reasonable to make some allowance for the influence of the price of margarine or real disposable income on the retail demand for butter. Table A, in *Economic Trends* No. 98 December 1961, corresponds in part to the period dealt with in this study, and shows that the index of average price of butter (1955 = 100) has varied between 70 and 117. (Average figures for 1955, 1956, 1957, 1958; quarterly averages for 1959, 1960.) In the same period, and on the same index scale, average price of margarine has only varied between 45 and 49. Quarterly averages over the four years 1958-1961, for consumption in ounces per head per week, given by the British Digest of Statistics Food Survey, show Butter and Margarine consumption to be highly correlated ( $r = -.94$ ). As is shown in the main body of this study, retail price and consumption of butter are closely related. The relatively stable price of margarine thus leads us to the tentative conclusion, based on the available information, that changes in margarine price have had little influence on changes in butter consumption; changes in margarine consumption being due to a substitution effect with butter rather than due to fluctuations in the price of margarine. If the price of margarine ceased to be relatively stable, steps would have to be taken to incorporate its influence on retail demand for butter into the model to be used. Similar remarks apply to the effect of real disposable income on the retail demand for butter. The Food Survey already quoted, gives the per head per week average expenditure on food as varying between 27s. 8d. and 30s. 1d., over the same four year period as before, 1958-1961. Over this period a correlation of  $r = +.23$  exists between expenditure on food per head and consumption of butter per head, based on quarterly averages. If no account was taken of changing food expenditure levels over a long period, the estimates obtained for retail demand based on weekly data, would be biased. However in this study, the overall period has been subdivided into three separate periods, thus reducing the risk of bias in the estimates. Income and Margarine price information was available to the authors only on a Quarterly basis, compared with a weekly basis for the important variables, retail price and consumption of butter. It was decided that any likely advantage of using Income or margarine price as explanatory variables would be outweighed by the resultant loss in information through using quarterly instead of weekly observations for retail price and consumption.

the partial derivative to zero results in the maximum expenditure co-ordinates given in Table 4. The calculated prices and quantities would be *correct if the calculated relationships were indeed the true relationships*. In fact the expenditure maximizing butter prices for Period II and III are 5/1 and 5/4 respectively, this is well outside the observed range of prices and involves serious extrapolation. The important point is that the evidence from June 1958 to March 1961 suggests that *if butter is above 2/6 lb. retail and less than 5/- lb. then the higher the retail price the higher the total expenditure on butter.*

TABLE 4.  
*Price and Quantity for Maximum Consumer Expenditure on Butter*

Period	Price per lb. $\bar{X}$	Quantity $\bar{Y}$	Expenditure (£m. per week) $\bar{E}$
I	2/-	11,544 tons	3.34
II	5/1	6,275 tons	£2.59
III	5/4	5,587 tons	3.57

In particular, between the beginning and end of Period III (21st November 1959 and 20th March 1961) there was a change from buying approximately 6,850 tons per week at 4/2 to 4/5 lb., to approximately 8,695 tons per week at 2/8 per lb. *An increase of 27% in the quantity consumed was associated with a decline in total consumer expenditure on butter of 21%.* On the other hand during Period I increasing supplies of butter appear to have increased total consumer expenditure on butter.<sup>15</sup>

#### *Use for Prediction*

The recent decision to limit the supplies of imported butter to the United Kingdom to 390,000 tons in the year ending 31st March 1963, permits us to estimate the likely price for butter. Between 1960 and 1961, the United Kingdom production of butter rose from 37,200 to 48,500 tons. As to whether this was the result of a particularly good season, or represents a trend, it is hard to say, but if we estimate that there will be a similar increase between 1961 and 1962, we can estimate United Kingdom production in 1962 as approximately 60,000 tons. This would result in 450,000 tons reaching the British market, or about 8,650 tons per week. It can be seen from Figure 6, that depending whether the relation for Period I or Period II holds, the likely retail price is in the range 2/6 to 3/4. This would result in a wholesale butter price in the range 240/- to 320/-, and

15. Attempts to find the expenditure maximizing quantity using the constant elasticity function lead to the ridiculous result that the quantity is zero or plus infinity depending as  $b$  is less or greater than minus one.

a total retail expenditure of approximately £m2.9 per week on butter in 1962-63.

### *Conclusions*

Estimates of the United Kingdom retail demand for butter, based on weekly figures have been reported. These estimates suggest an essentially stable demand relation over a period of years, albeit a relation which responds differently to falling and rising butter prices. The retail information available to the authors is insufficiently detailed to allow an analysis of demands for butter from different countries, and hence no estimates of cross-elasticities of demand could be obtained. If access could be obtained to a detailed survey of retail sales (say the A.C. Nielsen Service) then it is likely that very satisfactory cross-elasticities of demand could be estimated.