Marketing of butter in the EC: Demand functions and policy alternatives, with a restriction to four member countries*

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Summary

In this article optimum instrument values for two different objectives of an EC marketing policy for butter are considered.

In the first part of the study the demand equations of four EC countries, i.e., West Germany, the United Kingdom, the Netherlands and Denmark, are estimated and discussed. These countries cover about 58 percent of the total butter consumption of the EC. The second part contains the formulation of a maximum revenue policy and a budget minimizing policy. With each of these two different aims, the optimum price of butter is first determined. Then the optimum price of butter is considered simultaneously with optimum values of other policy instruments.

1. Introduction

During the last years butter has been a problem product for the agricultural policy in the EC. There has been almost continuously a surplus of butter which had to be stored in expensive cold storage buildings or exported to countries outside the Community at very low prices. So there was a discrepancy between production and demand. In this study we shall concentrate on the demand side of the butter problem. We shall examine the characteristics of

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the demand for butter and investigate their consequences for the marketing policy.

First we shall try to determine for the EC countries which factors influence the demand for butter and to quantify their effects. For this purpose demand equations for butter are formulated and their parameters estimated for the Netherlands, Western Germany, United Kingdom and Denmark. Unfortunately, for the other EC countries the necessary data for estimating the demand equations were either non-existent or beyond our financial means.

Then with the information obtained we will try to formulate a marketing policy for butter, which, given a certain objective and certain decision variables, is optimal. The major decision variable with which the European Commission can influence consumption of butter is the intervention price, which in practice determines the actual price of butter on the market. For this reason we will consider the price of butter as the most important marketing instrument. However, some other policy variables like the selling of cold stored butter at a reduced price will receive attention.

Because it was not possible to obtain data from all the EC members we cannot derive an optimal policy for the EC as a whole but only for a part of it. Although this is a drawback we feel that this partial optimization provides useful information. Moreover the methodology is the same for a part of the EC as for the whole and is directly applicable to the complete community.

The plan of this article is as follows: In section 2 we formulate the demand equations and present the estimation results, together with some appropriate comments. For those EC countries for which the demand equations could not be estimated, we give some global figures about butter consumption. In section 3 we try to find those values for a number of variables which lead to a marketing policy for butter which is optimal in a certain sense. Section 4 contains some concluding remarks.

2. The demand for butter

2.1 *Formulation of demand equations*

The first variable which may be expected to influence the demand for butter is its price. Also the price of the nearest substitute for butter, namely margarine, should be considered because of its effect on butter consumption. A further variable which might be of interest is income. Because of the possibility of a structural shift in the demand for butter, a trend variable should be included in the demand equation. When butter consumption refers to periods shorter than one year, which is so for our data, the possibility of different consumption levels in different seasons should be taken into account. Thus we obtain the following function:

(1) $C = f(P, P_m, I, T, D)$

where C = consumption of butter, P = price of butter, P_m = price of margarine, I = income, T = trend, D = dummy for variation in seasons (stands possibly for more than one seasonal dummy).

Throughout this study all variables on the right side of (1) are considered as exogenous. Because incomes have been increasing very regularly during the last ten years in Western Europe, the variables I and T will be highly intercorrelated. Moreover, for most countries there are no income figures available for periods of less than one year. For these reasons the variable I was eliminated from the demand equation. So (1) becomes:

(2) $C = f(P, P_m, T, D)$

A somewhat complicating factor is the existence of two different varieties of butter on the market of the countries of the 'old' EC. Here we consider the availability of regular butter, together with a lower priced butter – in the Netherlands under the name of 'koelhuisboter', in Germany called 'Molkereibutter'. We will refer to this lower priced butter as second-grade butter. Of course in the United Kingdom there are many different varieties of butter. We shall pay no attention to these differences but only to the second-grade butter in the old EC because this type of butter is a result of the common butter market policy. Its sale might be a good marketing instrument for future use. To include second-grade butter our notation becomes: C = total consumption of butter, C_1 = consumption of regular butter, C_2 = consumption of second-grade butter, P_1 = price of regular butter, P_2 = price of second-grade butter, P_w = weighted average price of regular and second-grade butter, P_d = price difference = $P_1 - P_2$.

For C_1 and C_2 we use the following functions:

(3) $C_2 = f(P_2, P_d, P_m, T, D)$

and

(4) $C_1 = f(P_1, C_2, P_m, T, D)$

So it is assumed that, when second-grade butter is available, first C_2 is determined and then C_1 as a function of C_2. The estimation of (3) is extensively discussed in Section 2.1.1. Quantities of butter, bought under other types of special programs are incorporated in the demand equation in a similar way to second-grade butter in (4).

The relationships between consumption of butter and the independent variables in equations (2), (3) and (4) are assumed to be linear. With respect to price this means that price elasticity increases when price increases, which seems to be realistic. Of course other function specifications might be considered, but for reasonable changes in the independent variables a linear approximation is always possible. With the specifications just mentioned, (2), for example, becomes:

(5) $C_i = \alpha_o + \alpha_1 P_i + \alpha_2 P_{mi} + \alpha_3 T_i + \alpha_4 D_i + U_i$

where i refers to period number. U_i is assumed to be normally distributed with expected value zero, constant variance and $EU_iU_j = 0$ for $i \neq j$.

Parameters are estimated with the method of least squares. When autocorrelation is likely the iterative Cochran-Orcutt procedure is used to remove it. For the theory of the methods used, see Johnston (1972) or Wonnacott and Wonnacott (1970).

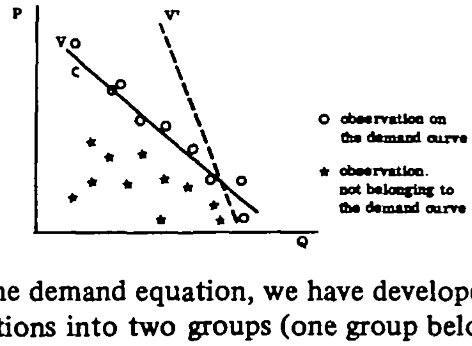
2.1.1 *Estimating the demand equation of second-grade butter*

The demand equation of second-grade butter gives special estimation difficulties. Only for some of the observations was second-grade butter available. However, it is not at all clear whether these observations belong to the demand curve. When supply falls short, some demand will be 'disappointed', and the observation does not belong to the demand curve. This situation has some relation to the 'markets in disequilibrium' problem, investigated by Fair and Jaffee (1972). These writers divided the observations on the housing market into those belonging to the demand curve and those belonging to the supply curve. However, supply and price of second-grade butter are both fixed by the authorities, so we cannot distribute the observations among the demand and supply curve. This situation is illustrated in Figure 1.

Since the observations which do not belong to the demand curve are autonomous,[1] the methods of Fair and Jaffee (1972) and Goldfeld and Quandt (1973) cannot be applied here.

1. The authorities may fix quantities and prices according to some supply curve. We shall not introduce this hypothesis.

Figure 1. *(Hyperthetical) observations on quantity and price of second-grade butter*



For estimating the demand equation, we have developed a procedure which divides the observations into two groups (one group belonging to the demand equation, the other not) and estimates the demand equation. This procedure is essentially iterative.

From a small number of observations, a preliminary demand function is estimated. So the observations of the dependent variable are divided into the vectors y and z, while for the elements of y the preliminary equation is estimated (here begins Stage 1) $y = X\hat{\beta} + \hat{u}$. X and W are matrices of observations of the independent variables, $\hat{\beta}$ is the vector of estimated parameters, $\hat{u}$ and $\hat{v}$ are vectors of estimated disturbances.

The parameters $\hat{\beta}$ are used for fixing the disturbances $\hat{v}$ of z, under the assumption that the particular element of z also belongs to the preliminary demand equation. So: $\hat{v} = z - W\hat{\beta}$. The greatest element of $\hat{v}$, say v_j, is added to the observations of the demand equation (when $\hat{v}_j > b(s)$; b is a limit, which depends on the estimated standard deviation of the disturbances u). A new partition is defined: $y_1 = \binom{y}{z_j}$ where $z_1 = z$ minus element z_j. And (perhaps) the demand equation is re-estimated. This procedure is repeated until, at the k^{th} step, all elements of the vector $\hat{v}_k$ are smaller than $b(s_k)$.

In the second stage, the element of the vector y_k, which corresponds to the smallest element of the vector $\hat{u}_k$, say $\hat{u}_l$, is removed when $\hat{u}_l < b(s_k)$. After removing an element of the y vector, the procedure jumps to Stage 1. After an always limited number of iterations, the procedure stops, and the last estimated equation is the demand equation (of second-grade butter).

There are two arbitrary elements in the above procedure: The initial observations for estimating the preliminary demand equation, and the limit $b(s_i)$ that depends on the estimated standard deviation of the disturbances. We will briefly discuss these points.

If we choose, for example, the largest 'quantities' as initial observations, we may find a curve V', whereas V is the right one (see Figure 1). We can overcome these difficulties by taking different groups of initial observations. When these different groups lead to the same demand equation, we can be quite sure of finding the right curve.

An optimal value for $b(s)$, which means a limit leading to the best linear unbiased estimate of the parameters, could not be derived. This derivation should be based on distributional assumptions for the observations which do not belong to the demand equation. We fixed $b(s)$ at $1.3 \times s_u$, where s_u is the estimated standard deviation of the disturbances. In this way, 10 percent of the observations on the demand equation are discarded for regressions with many observations relative to independent variables.[2] On the other hand some observations, which do not belong to the demand equation, can be incorporated.

2.2 *Estimated demand equations per country*

Data from a consumer panel are preferred to estimate the demand equations. These data most adequately reflect the behavior of the consumers. However, not all demand for butter originates from households. Especially in the Netherlands butter not directly consumed in households is relatively important, so a separate equation is estimated for this butter. The large number of observations per year (namely 13) is an additional advantage of panel data. So, reliable estimates can be established with data covering only a relative short period. This is a great asset for a market with a swift structural change.

On the one hand, it could be argued that the use of 'monthly' data, without any dynamic elements in the demand equation, leads to underestimation of price elasticity. Consumers would show some delayed reaction. On the other hand, stock changes in household, etc., and temporary substitution possibilities would lead to an overestimate of price elasticity. Although the use of annual data does not completely suppress a different short-term behavior, a comparison between the results for both types of data can be interesting. For household consumption in the Netherlands during the period 1958–1968, Wierenga (1969) found the difference between the price elasticities from 'monthly' and annual data to be negligible.

2. This percentage is less for our demand equations with relative few observations. Here the distribution of the estimated disturbances strongly differs from a normal distribution.

No consumer panel data were available for W. Germany and Denmark, so quarterly data for the whole market were used.

2.2.1 *The Netherlands*
Total butter consumption in the Netherlands in 1972 was 24,800 tons, which means 1.9 kg per head per year (Source: Produktschap voor Zuivel). Average retail price in 1972 was F17.50 = 2.13 Eurs per kg. (1 Eur, the standard EC money unit = 0.888671 gram gold).

From a comparison of total consumption with direct consumption of butter in households, it appears that the latter, called *domestic consumption* here, amounts to only 30 to 40 percent of total butter consumption. The remaining butter goes to restaurants and to bakers, biscuit industries, etc., to be processed in other products. Of course afterwards this butter may also be consumed in households, but indirectly. We designate this as *non-domestic consumption.* Because of the relative importance of non-domestic butter consumption in the Netherlands we estimated the demand equations separately for domestic and non-domestic consumption.

2.2.1.1 *Domestic consumption in the Netherlands.* Most data used originate from the NIAM[3] Consumer Panel. We received them via the 'Produktschap voor Zuivel'. Thus we have data per four weeks for consumption and prices of butter (both regular and second grade), measured by a consumer panel of 2000 households, representative of the Dutch population, living in households. Each year produces 13 observations, which can be numbered 1, 2, ..., 13. For the estimation we used the figures of the period 1965 to 1972. Three different demand equations were estimated – for all butter, second-grade butter and regular butter.

The exact definitions of the variables are:

C = total butter consumption in kg per 100 persons per four weeks
C_1 = the same for regular butter
C_2 = the same for second-grade butter
P_1 = price in cents per 250 gram, regular butter
P_2 = the same for second-grade butter
P_w = the same, weighted average of regular and second-grade butter

3. N.I.A.M. = Nederlands Instituut voor Agrarisch Marktonderzoek. (Netherlands Institute for Market Research on Agricultural Products).

P_d = price difference between regular and second-grade butter (prices are retail prices, deflated for the increase of costs of living)
T = trend: First period of 1965 = 1, second period of 1965 = 2, etc.
D_1 = 1 in the periods 4 to 6, 0 else
D_2 = 1 in the periods 7 to 9, 0 else
D_3 = 1 in the periods 10 to 13, 0 else
(D_1, D_2, D_3: seasonal dummies)

All butter. Estimated demand equation:

$$(6)\quad C = 27.435 - .109P_w - .072P_m - .084T + .286D_1 - .173D_2 + .874D_3$$

(t_{96})		(8.10)	(.85)	(11.42)	(1.12)	(.60)	(3.37)
sign		**		**			**

$n = 104$ $R^2 = .747$ $d = 1.74$

A short explanation of the way the results are presented is necessary. The quantities, in brackets below the regression coefficients, are the corresponding absolute t values, indicating whether the corresponding regression coefficients differ significantly from zero. Significance is indicated as follows: * = significant at the 5% level, ** = significant at the 1% level (two sided). R^2 is the coefficient of determination, d is the Durbin-Watson statistic, while n is the number of observations. After a correction for autocorrelation, the subscript of the t value plus the number of independent variables (incl. the constant term) is smaller than n.

Because the existence of two grades of butter at the same time may have special effects, we estimated the same function for the periods in which no second-grade butter was available. For these periods C coincides with C_1 and P_w with P_1. Thus we obtained for the periods with only regular butter:

$$(7)\quad C_1 = 34.864 - .120P_1 - .247P_m - .089T + .255D_1 - .458D_2 + .215D_3$$

(t_{57})		(4.63)	(3.84)	(18.02)	(.87)	(1.51)	(.73)
sign		**	**	**			

$n = 65$ $R^2 = .900$ $d = 1.80$

We see that total explanation is somewhat better than in (6). The equations (6) and (7) will be discussed after the presentation of some other results.

Second-grade butter. The demand equations for this type of butter are estimated according to the procedure discussed in Section 2.1.1. Because for some seasons there were very few observations, seasonal variation in second-grade butter consumption has not been investigated. If there are observations that do not belong to the demand curve, seasonal dummies will easily shift the demand curve in the direction of these observations. Three different groups of initial observations led to (nearly) the same equation. We present one of the results which started with the ten largest quantities.

$$\begin{array}{llllll} (8) & C_2 = 5.19 - .30P_2 & - .027P_d & + .86P_m & + .036T \\ & (t_{16}) \quad (6.65) & (.61) & (2.55) & (1.65) \\ & \text{sign} \quad ** & & * & \\ & n = 21 \quad R^2 = .917 & & d = 1.84 & \end{array}$$

[4]

The absolute level of the price of second-grade butter seems to be more important than the price difference.

Regular butter. Regular butter was available during all periods covered by our analysis. The estimated equation is:

$$\begin{array}{l} (9) \quad C_1 = 32.677 - .137P_1 - .605C_2 - .141P_m - .083T + .381D_1 - .032D_2 + .773D_3 \\ \quad (t_{94}) \quad (4.63) \quad (14.16)(1.84) \quad (12.86)(1.62)(.123)(3.27) \\ \quad \text{sign} \quad ** \quad ** \quad ** \quad ** \\ \quad n = 104 \quad R^2 = .833 \quad d = 1.84 \end{array}$$

In all equations butter price turns out to have a strong negative effect on butter consumption. Average (own) price elasticity of demand for all butter during all periods studied is − 1.36 [computed from (6)], while for the periods without second grade butter this elasticity is − 1.65 [(11)]. For second-grade butter average price elasticity is − 5.78 [(8)] and for regular butter − 2.11 [(9)][5]. So in all cases the absolute value of price elasticity is well above 1.0: Demand is very price-elastic.

The price of margarine has a significant negative influence on the consumption of regular butter in (7) and an almost significant (at the 5% level) negative influence in (9). It is surprising that these cross-price elasticities (which are − 0.06 and − 0.03, respectively) are negative because butter and margarine are substitute products. This phenomenon has been observed earlier and in this connection the hypothesis of a constant fat budget was suggested (Wierenga, 1969). A household is then assumed to spend a fixed budget on fats with the proportion of butter in total fat purchases as high as possible.

4. For these data there were some omissions in the time series, viz. the periods without sufficient amounts of second-grade butter, which makes the estimation of autocorrelation somewhat less reliable. This holds also for the equations (7), (11) and (15).

5. Of course the latter elasticities are not directly comparable with those for all butter. The function specifications differ, while further the price elasticity of demand for second-grade butter is computed on the basis of only a subset of the data.

When the price of the cheaper product – margarine – increases, and the same quantity is to be bought, one is forced to substitute butter by margarine in order to remain within the fixed budget.

If such a mechanism works, it is expected to be stronger when the difference between the prices of butter and margarine is larger because in that situation the characteristic of butter, being a luxury good, is more evident. Thus our finding, that there is no significant negative effect of the price of margarine on consumption of all butter and a positive effect on consumption of second-grade butter, equations (6) and (8), both being lower in price than regular butter, is consistent with the fixed budget hypothesis.

The large negative trend in the consumption of all and regular butter means an autonomous decline, evaluated at the 1972 consumption level, of about 18%. This is higher than for the other countries. Second-grade butter consumption shows a different trend development.

In (9) C_2 is regarded as an exogenous variable with respect to the consumption of regular butter. The value of the regression coefficient (= 0.605) implies that 60% of all second-grade butter has replaced regular butter.

The consumption of all and regular butter is relatively high in the last part of the year. The feast days in December will largely explain this.

2.2.1.2 *Non-domestic butter consumption in the Netherlands.* Figures for non-domestic butter consumption per period of four weeks were calculated as follows. Per period of four weeks we had available:

(a) The figure for the total quantity of butter 'delivered to retailers, large-scale consumers and consumers', which is the quantity of butter moving into consumption. This figure is published by the 'Produktschap voor Zuivel'. Quantities delivered to the army or for special social programs are discarded because they are relatively unimportant.

(b) The figure for total domestic butter consumption. This figure was obtained by multiplying the consumption per head, the quantity found from the consumer panel (section 2.2.1.1), by population size.

Now for each period the quantity (b) was subtracted from the corresponding quantity (a), which resulted in the figure for non-domestic butter consumption for that period. There is one difficulty, namely, the four-weekly periods of the two series do not exactly correspond. In fact non-domestic consumption was calculated by relating the two series in such a way that the figure sub (a) always refers to a period beginning two weeks earlier than the four-weekly period to which the figure sub (b) refers. A time lag is necessary because there is a certain time interval between the moment the butter enters the distribution channel and the moment it is bought by the ultimate consumer. Of course the lag of two weeks, used here, is arbitrary. Analogously to domestic consumption, non-domestic consumption includes second-grade butter besides regular butter over a number of periods. Because second-grade butter is made available primarily for domestic consumption and only a minor part is used indirectly for non-domestic consumption, an independent demand function of second-grade butter was not estimated for non-domestic use. Moreover, during some periods there was a special kind of butter available at a low price, and it was obligatory that this was processed by bakers, etc. Because these products belong to the category 19.08 according to the EC classification, we call this 19.08 butter. The data used refer to the period 1965 to the middle of 1972.

Exact definition of variables:

C = total non-domestic consumption of butter, in tons per four-weekly period
C_1 = the same for regular butter
C_2 = the same for second-grade butter
$C_{19.08}$ = the same for 19.08 butter
PP_1 = producers price in cents per 250 g for regular butter (CBS)
PP_w = producers price in cents per 250 g, weighted average for regular and second grade butter (CBS)
PI_m = index producer price for margarine, cooking fat and edible oils (1961 = 100) (CBS)

All prices are producer prices, deflated for the increase of the costs of living. Because fats other than margarine may be substituted for butter for processing, we used the compound index just given. Trend and seasonal dummies are as defined in 2.2.1.1.

Two equations were used, one for the consumption of all butter and one for the consumption of regular butter. The parameters of the first equation were estimated for two different sets of data: 1) For all periods and 2) for the periods during which only regular butter was available and no second-grade or 19.08 butter.

All butter. Results of estimation for all periods:

(10) $C=4894.15-39.36PP_w+15.05PI_m-12.37T+115.73D_1+202.44D_2+66.30D_3$

(t_{89})	(7.95)	(2.18)	(6.33)	(1.58)	(2.46)	(.89)
sign	**	*	**		*	

$n = 97 \quad R^2 = .67 \quad d = 2.06$

Periods with only regular butter:

$$
\begin{array}{llllllll}
(11) & C = 5708.65 - 41.16PP_w & + 7.77PI_m & - 13.35T & - 74.31D_1 & + 184.71D_2 & + 83.00D_3 \\
 & (t_{21}) \quad (6.40) & (1.04) & (6.23) & (.95) & (2.31) & (1.08) \\
 & \text{sign} \quad ** & & ** & & * & \\
 & n = 28 & R^2 = .970 & d = 1.81 & & &
\end{array}
$$

Regular butter.

$$
\begin{array}{lllllll}
(12) & C_1 = 3953.77 - 28.91PP_1 & + 13.26PI_m & - .564C_2 & - .532C_{19.08} & - 14.24T + \\
 & (t_{87}) \quad (4.66) & (2.45) & (7.96) & (6.20) & (9.15) \\
 & \text{sign} \quad ** & * & ** & ** & ** \\
 & 129.54D_1 & + 222.32D_2 & + 105.26D_3 & & \\
 & (2.09) & (3.28) & (1.67) & & \\
 & * & ** & & & \\
 & n = 97 & R^2 = .870 & d = 1.92 & &
\end{array}
$$

The price dependency of this market is clearly illustrated by computing the average (own) price elasticities of demand, which is for all butter – 2.28 [(10)]. For the periods with only regular butter, (11), the figure is – 2.31. Average price elasticity for regular butter, derived from (12), is – 2.07. So price elasticity for non-domestic consumption is high and at least of the same magnitude as for non-domestic consumption.

The price level of substitute products like margarine, edible oils, etc., appears to have a positive effect on all butter as well as regular butter consumption. The average cross price elasticities range from 0.4 to 0.8. Since non-domestic users are not assumed to operate with a fixed budget, the positive signs of the cross-price elasticities are as expected.

The evident negative trend implies, for the 1972 level of consumption, an annual decline of more than 10%. This is somewhat less than the decrease of 18% per year for the domestic consumption in the Netherlands.

The coefficients of the seasonal variables indicate that non-domestic butter consumption is relatively high in the middle of the year and especially in the periods 7 to 9, which cover roughly the period July-September.

There is a remarkable correspondence between the amount of regular butter replaced by second-grade butter (C_2) and 19.08 butter ($C_{19.08}$): 50 to 60 percent, a percentage which nearly equals the effect of second-grade butter on regular butter for domestic consumption [(9)].

2.2.2 *United Kingdom*

Total butter consumption in the United Kingdom in 1972 was 391,000 tons, an average consumption per head of 7.0 kg. Average retail price in 1972 was £ 0.51 or 1.22 Eurs per kg. We will only consider domestic consumption. A comparison of domestic consumption with total consumption shows that domestic consumption is by far the most important; it is about 80% of total consumption.

The data available are of the same type as those for the Netherlands. The data per four weeks originate from a consumer panel, the Attwood Consumer Panel, consisting in the U.K. of 4000 households. We obtained these figures via the 'Nederlands Zuivelbureau'. From the data about consumption of and expenditures on butter and margarine, average prices could be calculated. We do not differentiate between the grades of butter and margarine on the British market.

The data used refer to the period 1965 to the middle of 1973. The exact definitions of the variables used are:

C = consumption of butter in lbs per 100 persons per four weeks
P = price of butter in 1/20 £ (5 newpence) per lb
P_m = price of margarine in 1/20 £ per lb

Prices are retail prices, deflated for the increase of the cost of living.
Trend and seasonal dummies are as defined in Section 2.1.1.1.

Result of estimation:

$$(13)\quad C = 180.83 - 17.56P + 6.31P_m - .36T + .49D_1 - 4.39D_2 + 1.82D_3$$

$$\begin{array}{llllllll} (t_{105}) & & (4.80) & (.38) & (5.90) & (.49) & (3.74) & (1.76) \\ \text{sign} & & ** & & ** & & ** & \\ n = 113 & & R^2 = .60 & & d = 1.89 & & & \end{array}$$

For this market the average price elasticity of demand is − 0.43. This is much lower than the corresponding figure for the Netherlands, but it should be kept in mind that the butter price in the U.K. is much lower than in the Netherlands. The price coefficient of margarine implies a cross-price elasticity of 0.09. Since prices of butter and margarine have been nearly equal in the U.K., a positive cross-price elasticity is expected.

These results are not far different from the figures on household food consumption and expenditure published by the Ministry of Agriculture, Fisheries and Food (1973). For the period 1964–1971, a different sample led to average elasticities of − 0.51 and 0.23 with respect to the prices of butter and margarine, respectively.

There is a downward trend in butter consumption which, for the 1972 level of consumption, means an annual decline of about 4%.

2.2.3 *West Germany*

In 1972 the total butter consumption in Western Germany was 437,000 tons, which means a consumption per head of 7.1 kg per year. The total butter consumption includes different types of butter, e.g., regular butter, second-grade butter, butter sold under special arrangements and 'home consumption'. The last type is not of considerable importance. The average (weighted) retail price of regular and second-grade butter was in 1972: 7.99 DM/kg = 2.28 Eurs/kg.

The quarterly data, as given in two studies of Metzdorf and Schmidt (1972, 1973) have been used for estimating the demand functions of all, regular and second-grade butter, where all butter is the sum of the last two components. The data pertain to the period from the third quarter of 1965 until the second quarter of 1973. Unlike the data from the Netherlands and the U.K., those for West Germany (and also Denmark) concern both domestic and non-domestic consumption.

Metzdorf and Schmidt (1973) noticed a structural change in the consumption of fats at the beginning of 1971. It is possible to test whether there has been a structural change in the demand for all and regular butter. For second-grade butter, this test could not be combined with our method of estimation because of a too-limited number of observations.

A formal procedure for testing for a structural change has been developed by G. C. Chow (1960). The test uses a F^{k}_{n-2k}-statistic, where k is the number of parameters and n the number of observations for the whole period.

For the German butter market, the F-values of the original regression equations were:

all butter: $F^{6}_{20} = 18.1$ (1% critical value: 3.87), independent variables: constant, P_w, P_m, SA, T and D_1.

regular butter: $F^{7}_{18} = 14.1$ (1% critical value: 3.86), independent variables: constant, P_1, P_m, C_2, SA, T and D_1.

The meaning of the variables is explained below. It is obvious that there was a structural change in the demand for butter within the period of estimation.

A structural change of the demand function can be a shift (change of the constant), a rotation (change of one or more of the other parameters) or both.

We used the 'stepwise regression' method, discussed in Draper and Smith (1968), for analyzing the change in parameter values. In using 'stepwise regression' the initial number of variables is somewhat arbitrary. This is not a problem here because we are only looking for structural change. So the number of variables is already fixed by the type of demand function that we use. The significance level (10%) of taking up an additional shift or rotation variable is a matter of choice.

The second-grade butter demand equation is estimated according to the procedure, as stated in Section 2.1.1. The ten largest quantities (of second-grade butter) acted as initial observations.[6]

The exact definitions of the variables used are:

C = consumption of regular + second-grade butter in kg per head per quarter
C_1 = the same for regular butter
C_2 = the same for second-grade butter
SA = the same for butter sold under special arrangements
P_w = weighted average price of regular and second-grade butter in DM/kg
P_1 = price of regular butter in DM/kg
P_2 = price of second-grade butter in DM/kg
P_d = price difference between regular and second-grade butter in DM/kg
P_m = price of margarine in DM/kg
(prices are retail prices, deflated by the index of food prices: 1968, 1969 = 1.00).
T = trend: 1965, third quarter = 1; fourth quarter = 2, etc.
D_1 = 1 in the first quarter, 0 else
D_2 = 1 in 1971, 1972, 1973 and 0 else (dummy variable for structural change).

6. Only the observation for the first quarter of 1970 (39,500 tons) was incomprehensible, also in connection with the opinion of Metzdorf and Schmidt (1973) that about 100,000 tons of second-grade butter could be placed annually on the West German market. This observation has been omitted.

The following demand equations resulted:
All butter.

$$(14)\quad C = 3.287 - .13P_w - .053P_m - .456SA - .0074T - .164D_1 + .64D_2 - .031D_2T + .082D_2D_1$$

(t_{23})	(1.63)	(.23)	(1.99)	(2.57)	(5.59)	(2.02)	(2.64)	(1.72)
sign				*	**		*	

$n = 32$ $R^2 = .885$ $d = 1.50$

Second-grade butter.

$$(15)\quad C_2 = -.357 - .14P_2 - .014P_d + .61P_m - .14SA + .002T$$

(t_5)	(3.10)	(.32)	(4.21)	(.58)	(.91)
sign	*		**		

$n = 11$ $R^2 = .898$ $d = 1.88$

Regular butter.

$$(16)\quad C_1 = 2.386 - .047P_1 - .037P_m - .537C_2 - .468SA - .0043T - .163D_1 + .93D_2 - .037D_2T + .06D_2D_1$$

(t_{22})	(.81)	(.23)	(5.78)	(2.76)	(1.90)	(7.58)	(3.87)	(4.25)	(1.69)
sign			**	*		**	**	**	

$n = 32$ $R^2 = .923$ $d = 2.10$

The average price elasticity with respect to their own price of all, regular and second-grade butter are -0.50, -0.23 and -2.16, respectively. The special influence of the price difference has to be kept in mind. If the regular butter price remains constant and the price difference changes, then the average elasticity with respect to P_d is 0.18.

The influence of the price of margarine on butter consumption is nearly the same as for the Netherlands domestic market. Although negative coefficients are not significant, we refer to the discussion of domestic butter consumption in the Netherlands.

One kilogram of second-grade decreases the regular butter consumption with just more than 0.5 kilogram. This result closely corresponds with the Netherlands figures. The effect of selling SA-butter on the consumption of the other types cannot be neglected. According to (14) one kilogram of SA-butter replaces about 0.45 kilogram of regular and second-grade butter. According to equations (15) and (16) the replacement is about 0.53 kilogram.

The consumption of regular butter shows a strong and increasing negative trend, which stood at 11% per year in 1972, while the demand for all butter had a smaller negative trend of 9% in 1972. This is because of a different trend for second-grade butter demand.

There is a considerable shift of regular butter consumption in the first quarter. Perhaps this is caused by a decreased consumption of luxury food after the feast days in December. The fluctuation levels off somewhat. This is partly caused by a lower consumption level. The variables combined with D_2 reflect the structural change in the demand for all and regular butter at the end of 1970.

2.2.4 *Denmark*

In 1972, the total butter consumption in Denmark was over 43,000 tons, a consumption per head of 8.6 kg. The average retail price during 1972 was 14.04 Kr./kg = 1.85 Eurs/kg. Because of a special home market arrangement in 1972, the prices of butter in Denmark were not much lower than in the 'old' EC.

The available quarterly data (as published by *Danmark Statistik*) pertain to the total consumption of (salted) butter and cover the period 1967 until the first quarter of 1973. Butter in Denmark is a very uniform product.

The exact definitions of the variables used are:

C = consumption of butter in kg per head and per quarter
P = deflated retail price of butter in Kroner per kg
(The index of food prices, 1964 = 1.00, was used as a deflator).
P_m = the same for margarine
T = trend; 1967, first quarter = 1; 1967, second quarter = 2, etc.
D = 1 for the first quarter of a year, 0 else

Estimated demand function for butter:

(17) $C = 3.14 - .086P + .028P_m - .017T - .13D$
(t_{20}) (1.51) (.64) (6.44) (5.37)
sign ** **
$n = 25$ $R^2 = .88$ $d = 2.59$

The estimated coefficient of P implies an average (own) price elasticity of − 0.32 and also a price elasticity of − 0.32 for the 1972 values of P and C. The average elasticity with respect to the price of margarine is 0.04. So, butter consumption in Denmark is not very price dependent.

There is a reliable downward trend in the consumption of butter which was 3% per year for the consumption level of 1972. This trend is much lower than the estimated trend for the Netherlands and West Germany, but nearly equals the trend for the U.K. In the first quarter of the year the demand function makes a considerable shift to the left. This phenomenon corresponds with the results for Western Germany.

Table 1. *Summary of demand elasticities for butter with respect to own prices for four EC countries*

Type of butter and period of evaluation		Netherlands domestic consumption	Netherlands non-domestic consumption	U.K.	West Germany	Denmark
All	average of estimation period	– 1.36	– 2.28	– 0.43	– 0.50	– 0.32
	1972	– 2.02	– 3.14[1]	– 0.59	– 0.52	– 0.32
Regular	average of estimation period	– 2.11	– 2.07		– 0.23	
	1972	– 1.95	– 3.47		– 0.21	
Second-grade	The second-grade butter campaign of 1969/70	– 3.50			– 1.82	

1. 1971

2.3 *Some information about butter consumption in other EC countries*

The available statistics of France, Italy, Belgium + Luxembourg and Ireland do not justify the same type of econometric research. For the convenience of the reader Table 2 gives some information for these countries. The real price of butter is obtained by deflating with the index of consumer prices.

These figures indicate a stable consumption level for Italy and Ireland and a decreasing consumption of butter for France and Belgium + Luxembourg. However, the strong decrease in consumption can be caused partly by cutting out consumption stimulating measures. The important position of France and to a lesser extent Italy and Belgium + Luxembourg makes it clear that these countries cannot be excluded when a real decision is made for the whole EC.

Table 2. *Some statistical information on butter consumption for France, Italy, Belgium + Luxembourg and Ireland*

Year	France			Italy			Belgium + Luxembourg			Ireland		
	C=Total consumption (1000 tons)	*C/h*=Consumption per head in kg	*P*='Real' butter price[1]	*C*	*C/h*	*P*[1]	*C*	*C/h*	*P*[1,2]	*C*	*C/h*	*P*[1]
1969	*d*	*d*	95.9	103.5	1.9	102.2	102.2	10.2	105.9	34	11.7	111.1
70	458	9.0	94.6	105.0	2.0	101.7	98.6	9.8	101.2	35	11.8	105.5
71	427	8.3	100.4	109.5	2.0	101.7	83.2	8.3	101.7	37	12.5	98.2
72	413	8.0	100	105.5	1.9	100	81.7	7.7	100	37	12.2	100
Percentage of total EC consumption[3]	27.0			6.9			5.3			2,3		
Nominal price in Eur/kg[3]	2.30			2.61			2.33			1.47		

d means not available because of a discontinuity in the statistical sources
1. Base year 1972 = 100; retail price
2. only creamery butter
3. In 1972

3. Optimum instrument values for the European butter policy

3.1 *Framework and assumptions*

To formulate an optimum marketing policy for butter, the following questions have to be answered:

a) What is an optimum policy.
b) Which instruments can be used for achieving an optimum policy.
c) What are the relations between the instrument values and the aims of a policy.

Although the definition of an optimum policy is not necessarily limited to the framework of the Common Market Agricultural Policy (CAP), some characteristics of the CAP on milk will be discussed. Then the reader can understand better the way in which optimization takes place, together with the necessary assumptions.

The price of milk in the EC is supported by the price of butter and the price of skimmed milk powder.[7] The intervention prices of these two components of milk nearly fix the minimum price of milk. There is a strong policy constraint upon the minimum price of milk because this price is one of the instruments for supporting a reasonable average income for farmers. Therefore, in the short run, the minimum price of milk can be seen as independent of the marketing possibilities for butter and skimmed milk powder. Given this framework, the European Community has to fix the ratio between the prices of butter and skimmed milk powder, together with the additional instruments such as: price of second-grade butter, quantity of butter sold under special arrangements, subsidy on the use of skimmed milk powder in feeding stuffs, etc.

In this study two types of an optimum policy will be considered.

A) From the demand functions, as stated in section 2, the maximum total revenue of a given quantity of butter can be computed. One can see such a 'maximum revenue price' of butter as a partial optimum for a policy with the following target: Finding the maximum revenue of a given quantity of milk. Of course, such an aim is not required to be in accordance with the CAP, where the income of the farmers as well as reasonable prices for the consumer are objectives.

A different look upon a maximum revenue price requires an additional

7. Except Italy where the support is based upon three different types of cheese.

policy instrument. If the producer's price of butter is detached from the consumer's price, the difference between them would be an excise or a consumer subsidy. In this context a 'maximum revenue price' is a short-run budget minimizing policy under the monopoly behavior of the European Community. The term monopoly behavior is used here since both the price for the producer and consumer of butter are independently regulated by the Community.

B) A second type is the minimum total budget that can be organized by using only the present-day instruments of the CAP. Here the price of milk is a constraint and the budget for the dairy policy is within the objective function.

The fundamental relation of the EC dairy policy is:

$$(18)\ a.p_b + b.p_s = p_m$$

where p_b, p_s and p_m are the prices of butter, skimmed milk powder and milk, respectively; a and b are technical coefficients, which depend on the composition of milk. Within the framework of the CAP, the price of skimmed milk powder can be derived from the price of butter.

Since the total budget contains a butter component and a skimmed milk powder component, the marketing policy instruments for butter have to be fixed at a level which minimizes the sum of the two components. However, the minimum conditions have to be based upon some assumptions about the skimmed milk market.

Both types of policies can neglect the interests of the consumer, so they are not exhaustive. The welfare economic aspects of the instrumental values could be taken into account. Because of the limited number of empirically stated demand functions we must make do with these two possibilities.

The instruments considered are all actually used in the EC butter policy. Only the influence of exported butter on the world market prices was not quantified. For exported butter some different assumptions are used.

Because only four EC countries are considered in the optimization procedure (in 1972 these four countries covered 58% of the total butter consumption), general conclusions about the EC dairy policy are not allowed. Moreover, the demand functions for second-grade butter are only known for Western Germany and the Netherlands. The same holds for the influence of 'special arrangement' (SA) butter on the consumption of the other types. These limitations should be borne in mind when the results which follow are judged.

Table 3. *Demand equations for all butter, regular butter and second-grade butter for 1972. The regression coefficients given correspond with the variables in the headings of the columns.*
The number in the last column indicates the equation number of section 2 from which the given equation is derived. Quantities are in 1000 tons, prices in Eurs/kg. Prices are producer prices [1]

(a) *All butter: C*

Country	Constant	P_w = weighted average price	Equation number
Netherlands (domestic)	27.30	– 9.89	6
Netherlands (non-domestic)	63.03	– 26.68	10
United Kingdom	608.53	– 172.55	13
Germany	615.66	– 96.97	14
Denmark	54.04	– 7.33	17
Aggregate	1368.56	– 313.42	

(b) *Regular butter:* C_1

Country	Constant	P_1; price of regular butter	C_2 = consumption of second-grade butter	SA = butter under spec. arrangements[2]	Equation number
Netherlands (dom.)	32.25	– 12.33	– .605		9
Netherlands (non-domestic)	47.07	– 19.60	– .564	– .532	12
Germany	481.15	– 35.36	– .537	– .468	16

(c) *Second-grade butter:* C_2

Country	Constant	P_2 = price of second-grade butter	P_d = price difference reg. and sec.-gr. butter	SA = butter under spec. arrangements	Equation number
Netherlands (dom.)	49.65	– 27.09	– 2.44		8
Germany	327.85	– 105.20	– 10.07	– .139	15

1. The retail margins applied to the four countries in the order of Table 3 (a) are: .295, .184, .386 and .269
2. In the Netherlands called 19.08 butter.

The whole optimization is performed with the 1972 levels of the exogenous variables. This is the most recent year for which all these variables are known. Throughout this whole section the following assumptions are made:

a) Supply of butter is independent of the price of butter. Butter production is based on two production processes – i.e., directly producing butter and skimmed milk and producing other (partly) unfattened milk products. The first process is unaffected by a change in butter price if this change is compensated by the price of skimmed milk powder. A change of the butter price affects the price and demand of milk products which do not have the original composition of fats and proteins. This assumption boils down to a price-inelastic demand for these products.
b) The retail margin is independent of the wholesale price. This assumption was checked in a regression where the (deflated) wholesale price was one of the variables that explained the (deflated) retail margin. This regression was used on the price data for the Netherlands, West Germany and Denmark. For all the countries, the coefficient of the wholesale price was small and not significantly different from zero at the 10% level.
c) Point estimates of regression coefficients are used, so that the stochastic aspects of demand are neglected.

The next section gives the demand functions for butter with price and quantity variables, defined uniformly, i.e., in the same quantities. In section 3.3 the price of butter, the most important instrument, will be analyzed. Because the demand equations for all butter were the most reliable ones, they will be used throughout this section.

In section 4 all the instruments of the butter policy are considered. Here the analysis is based on the demand equations for regular and second-grade butter. The sections 3.3 and 3.4 deal first with the maximum revenue policy and next with the minimum budget policy.

Section 5 contains a short evaluation of the results of the optimization.

3.2 *Demand functions with uniformly defined variables*

In section 2 the demand functions for butter are given in national currency and typical units for quantities. Rewriting all functions in the same unit makes them easier to handle. Moreover, the exogenous variables (price of margarine, trend, etc.) have to be given some value. Throughout the whole optimization procedure, the exogenous variables will be fixed at the average values of 1972. Also the retail margins and the exchange rates are fixed at

1972 levels. For the U.K. total demand for butter was assumed to be $\frac{100}{80}$ times domestic demand. The assumption that the price demand elasticity for non-domestic and domestic consumption is the same is in accordance with the results of the Netherlands demand functions.

Table 3 gives the resulting demand functions for all, regular and second-grade butter.

3.3 *Optimum marketing policy, when only the price of butter is considered as an instrument*

As already mentioned, throughout this section the demand equations for all butter are used. Before the two different types of optimum policy are investigated, the values and choices of some exogenous variables are explained. The total supply of butter (S), including imported butter from New Zealand (which was 118,000 tons in 1972), was 1,008,100 tons. However, the 'nine' EC countries, which made up the EC at the beginning of 1973, had a net export to all other countries of 79,000 tons in 1972. Since we are computing optimum instrument values for four EC countries, with 58% of the total consumption, the same percentage is used for the export of the 'four' countries. So, the 'normal' export (E_1) is 46,000 tons. The price of 'normal' export butter (PE_1) is fixed at the average price in 1972 for butter exported by the 'six' EC countries. This price was 0.96 Eurs/kg.

The EC cannot significantly increase butter export on the same price level. When supply of butter exceeds internal consumption and 'normal' exports, the surplus will be called extraordinary export (E_2). Then optimum policies are computed for two values of the price of E_2: PE_2 = 0.30 Eurs/kg and PE_2 = 0. The first price is the actual price for butter realized in April 1973 for a special transaction of 200,000 tons with the USSR.

3.3.1 *Maximization of total revenue*

In this section the aim is to maximize total revenue of butter, where the only marketing instrument considered is the butter price. The computation is based on the demand equation for all butter, given in Table 3 (a). Total revenue is maximum when the marginal revenue of butter sold on the home market is equal to the opportunity return, i.e., when the butter is exported.

Maximization was first done for the four countries as a unit, indicated as EC-4. Here the aggregate demand equation from Table 3 (a) was used. The maximization was also done for each of the four countries separately after which the results were added.

Table 4. *Price, consumption and revenue of butter for maximum revenue and actual calues of butter prices.*
(a) 4 countries as a unit;
(b) 4 countries separately.
Internal revenue = revenue of internally consumed butter;
Total revenue = internal revenue + revenue from exports

Country	$PE_2 = .30$				$PE_2 = .0$				Actual situation			
	Price	Cons	Intern. revenue	Total revenue	*Price*	Cons	Intern. revenue	Total revenue	*Price*	Cons	Intern. revenue	Total revenue
(a)												
EC-4	2.33	683.3[1]	1487.2	1628.5	2.18	685.4	1493.9	1538.1				
(b)												
Netherlands	1.38	39.7	54.8		1.23	45.2	55.6		1.83	24.8	45.4	
U.K.	1.91	278.4	531.7		1.76	304.9	536.6		1.04	390.9	406.5	
Germany	3.32	293.3	973.8		3.17	308.3	977.3		1.91	437.2	835.1	
Denmark	3.83	25.9	99.2		3.68	27.0	99.4		1.58	42.9	67.8	
4 EC countries total		683.3[1]	1659.5	1800.8		685.4	1668.9	1713.1	1.51	895.8	1354.8	1418.9

1. These quantities are equal because of the maximization based on linear demand equations.

The resulting figures for butter prices with the corresponding consumption levels are presented in Table 4. For a comparison the actual values (for 1972) are also given. The revenue is given for the butter internally consumed, as well as for total butter sales, inclusive of exports. Here the starting point was a total amount of butter of 1008.1 (× 10^3 tons), of which a maximum quantity of 46 could be exported at a price of 0.96 Eurs/kg and the surplus at a price PE_2, which was assumed to be 0.30 and 0 respectively.

From the results given in Table 4 the following conclusions can be drawn.

(1) For PE_2 = 0.30 optimum price in the EC-4 is 2.33; for PE_1 = 0; this price is 2.18 which is only slightly lower. For both values the optimum price is above the actual (weighted) average price of 1.51. So when the aim is to maximize total revenue of butter, the price should be raised. The proposals of the EC commission go in the other direction, i.e., a decrease in the butter price is proposed.

(2) Statement (1) applies to the 4 EC countries as a whole. There are big differences between individual countries, however. For the Netherlands, where price elasticity is large, a decrease of the butter price would increase total revenue. Also for the United Kingdom a price lower than the common optimum of 2.18 or 2.33 would result in a higher revenue. For Germany and Denmark, the reverse holds. Both facts imply that total revenue for the four countries together can be increased by fixing the butter price separately for each country. When full use is made of price discrimination, as can be seen from Table 4, total revenue of butter can be increased by more than 170 million Eurs. Thus the requirement of equal consumer prices in all EC countries can prevent use being made of all the possibilities of the market.

(3) In the actual situation, where total consumption within the four countries is much bigger than in the optimum situation, every additional export is a relief for the internal market which always results in a higher total revenue. So the transaction with Russia was a profitable one in the given situation.

(4) Maximization of total revenue implies a substantial decrease in internal consumption, viz. from 895.8 to 685.4, and 638.3. These values are dependent on the assumption for the marginal revenue. It should be emphasized that production costs of additional butter have not been included when these data were derived. It is not likely that surpluses, arising when total production remains at the same level, can be sold

abroad. Hence, when the aim is to maximize total revenue of butter, butter production should be strongly decreased.

3.3.2 *Minimum budget*

Since the total budget corresponding to the instrument values of the marketing policy for butter are related to the skimmed milk market, some characteristics of this market are considered. Skimmed milk is usually produced together with butter. So, as for butter, it is realistic to assume that skimmed milk production is independent of its own price, when there is compensation by the butter price.

In 1972 the market for skimmed milk powder of the 'six' EC countries contained the following categories:

Human consumption (Q_H)	8%
Used against a reduced price in feedings stuffs (Q_F)	83%
Export against world market prices (Q_E)	3%
Export for food aid (Q_{FA})	4%
Stockbuilding (Q_{ST})	2%

These percentages are taken as representative for the total market of the EC. With respect to this market the following assumptions are used:

(a) The demand for skimmed milk powder used for human consumption in the EC is independent of its price.

(b) There is a policy constraint upon the price of skimmed milk powder used in feeding stuffs (P_F). This assumption agrees with the actual policy of the last years.

(c) The export price is exogenous.

Both P_F and the price for exported skimmed milk powder (PEX_s) are set at the average 1972/73 level of P_F, i.e., 0.36 Eurs/kg. Because very little skimmed milk powder is exported, the real level of PEX_s was not examined. The prices, according to which stock changes and food aid were evaluated were assumed to be zero. The level of these prices up to a very high limit have no influence on the optimum instrument values. Only the estimated level of the budget is influenced.[8] Since the supply of butter and skimmed milk powder and also the internal human consumption of the latter influence the optimum instrument value, Table 5 also shows the results of the sensitivity analysis for these quantities.

8. The same holds for imported butter from New Zealand. This quantity is not distinguished in computing the budget.

In 1972 the total skimmed milk powder production of the 'nine' EC countries amounted to 1.645 (X 10^3) tons. It seems reasonable to include 58% of this production in the budget equation, which is the share of butter supply and demand of the 'four' EC countries in the Community of the 'nine'. This choice implies a general budget minimum for the nine EC countries, when the price elasticity of demand for butter (evaluated at the optimum price level of the 'four' EC countries) is the same for the investigated as well as the non-investigated part of the EC.

Hence the definition of the total budget is:

$$B = E_2 (P_w - PE_2) + E_1 (P_w - PE_1) + .58 \; \{(Q_F + Q_E)(P_s - P_F) + (Q_{FA} + Q_{ST}) P_s\}$$

or, because $E_2 = S\text{-}C\text{-}E_1$

$$(19) \; B = (S\text{-}C)(P_w - PE_2) - E_1 (PE_1 - PE_2) + .58 \; \{(Q_F + Q_E)(P_s - P_F) + (Q_{FA} + Q_{ST}) P_s\}$$

with the restrictions: $C + E_1 \leq S$

$E_1 \leq 46$

S, C, P_w, E_2, PE_2, E_1 and PE_1 are defined in the earlier part of section 3.3. The meaning of Q_F, Q_E, Q_{FA} and Q_S, which summed are equal to Q_T, and P_F are stated above, while P_s is the price of skimmed milk powder.

As already mentioned, the demand equation for all butter (with constant and price coefficient α_o and α_1, respectively) is used. So the budget equation is:

$$(19a) \; B = (S\text{-}\alpha_o - \alpha_1 P_w)(P_w - PE_2) - E_1 (PE_1 - PE_2) + .58 \; \{Q_T . P_s - (Q_F + Q_E) P_F\}$$

The minimum budget is attained at $\frac{dB}{dP_w} = 0$, since for every positive value of P_w the second order conditions for a minimum are fulfilled ($\alpha_1 < 0$). Differentation of (19a) gives:

$$(20) \; S\text{-}\alpha_o - (2P_w - PE_2)\,\alpha_1 + .58\, Q_T - (a/b) = 0$$

where a and b are the technical coefficients from (18). The only exogenous variables which influence the optimum level of P_w are the supply of butter (S), the price of extraordinary export of butter (PE_2) and Q_T which equals total supply minus internal human consumption of skimmed milk powder.

In Table 5 some interesting figures are recorded for two levels of PE_2. The sensivity analysis is based on $PE_2 = 0.3$. The rows 1 and 2 are based on 1972 levels of supply. The only difference between these two rows is the assumed price of extraordinary exports. From a budgetary point of view the optimal butter price is much lower than the intervention price of 1972/73. When the marginal export price is zero, the difference between supply and home market consumption plus normal export nearly disappears.

Row 3 contains the actual intervention price of butter, which leads to a strong increase of extraordinary exports and total revenue of butter. Extra budget costs, compared with the optimum price, are estimated at 52 million Eurs for the four EC countries.

In the rows 4, 5 and 6 alternative assumptions are used for the supply of skimmed milk powder and butter and for the human consumption of skimmed milk powder. All figures should be compared with the corresponding figures of row 1 ($PE_2 = 0.3$). Since butter and skimmed milk powder production are not completely complementary, independent changes in butter and skimmed milk powder production are possible.

If the increased price of skimmed milk powder gives a 10% increase in supply, the optimum price of butter increases by .07 Eurs/kg. Additional budget costs are quantified at 71 million Eurs, under the assumption of a price equal to zero for the additional quantity.

A 5% decrease of the supplied quantity of butter reduces the budget costs by 59 million Eurs, while the optimum butter price increases by .08 Eurs/kg.

As can be seen from row 6, the size of home-market consumption of skimmed milk powder for human purposes is not very important.

The results of the sensitivity analysis can be interpolated and extrapolated. Extrapolation has to be limited sometimes, for example, for butter until there is a 9.8% decrease in supply, when the first restriction in (19) becomes active.

On the whole it seems justified to concluded that budget costs are sensitive to price setting, while the optimum price is not very sensitive to changes in supply and demand. The knowledge of marginal export prices is of considerable importance.

3.4 *An optimum marketing policy with additional instruments*

In this section, besides the price of butter, we consider as instruments the quantity of second-grade butter in terms of the price difference between regular and second-grade butter, and the quantity of SA butter. The computation is based on the regular and second-grade butter demand equations of West Germany and the Netherlands.

Table 5. *Figures for a budget minimizing policy with the price of butter as instrument, compared with the intervention price of butter for the 'six' EC countries in 1972/73*

Levels of supply, demand and the price of extra-ordinary export of butter	Optimum price of butter (Eurs/kg)	Home-market consumption (X 10^3 tons)	Export (X 10^3 tons) Normal	Extra-ordinary	Total revenue of butter (million Eurs)	Total[2] budget (million Eurs)	Price of[2] skimmed milk powder (Eurs/kg)
1. PE_2 = .3; 1972 levels	1.45	914	46	48	1384	494	.752
2. PE_2 = 0; levels	1.30	961	46	1	1292	515	.830
3. Actual prices of 1972	1.86[1]	786	46	176	1558	546	.540
4. Skimmed milk powder production 10% higher	1.52	892	46	70	1421	565	.716
5. Butter supply 5% lower	1.53	889	46	23	1411	435	.711
6. Human consumption of skimmed milk powder 10% lower	1.46	912	46	50	1387	501	.749

1. This is not an optimum price but the intervention price of butter during 1972/73 for the 'six' EC countries. Remark the difference between the intervention price and the 'actual situation' in Table 4. Thus, the effect of a lower actual butter price in the U.K. and Denmark are not considered in computing the level of the budget.
2. In the relation $a.p_b + b.p_s = p_m$: $a = 4.40$ $b = 8.51$, $a/b = .518$ while $p_m = 12.79$ Eurs/100 kg milk, which is the intervention price of manufactured milk (in the form of butter and skimmed milk powder) in the milk price year 1972/73. The technical coefficients are based on a 3.7% fat content; p_b and p_s are defined in Eurs/kg.

The effects of these additional instruments upon the markets of the U.K. and Denmark could not be quantified. In a real policy situation it is unlikely that the EC would use the instruments only for West Germany and the Netherlands.

The type of functions used makes it impossible to distinguish how much *SA* butter can be placed on a market. The only restriction would be: C_1 and/or $C_2 \geqslant 0$. It seems more reasonable to take the following limit: The maximum quantity of *SA* butter consumed in one year within the estimation period, namely 41,500 tons for West Germany and 11,500 tons for the Netherlands (the price of *SA* butter is fixed at the actual Netherlands figure for 1972, viz. 0.55 Eurs/kg).

The same problem occurs with second-grade butter for non-domestic consumption in the Netherlands (Q_2^N), which had a maximum of 3900 tons. For this part of the Netherlands market no explicit equation was estimated. Because domestic and non-domestic markets cannot be discriminated from the supply side, the optimal price difference between regular and second-grade butter is derived from the domestic demand equation only. Moreover, in the range 0 – 3900 tons for Q_2^N we added the relation $Q_2^N = .64C_2^N$, which was the actual ratio between domestic (C_2^N) and non-domestic consumption during the second-grade butter campaign of 1969–1970.

The demand equations for second-grade butter do not satisfy the very plausible condition that the consumption of this type will be zero, if there is no price difference with regular butter. As stated in section 2, only above some level of supply and thus some level of price difference can the consumption of second-grade butter be seen as endogenous. So we consider these demand equations as defined for a price difference which is not less than 0.15 Eurs/kg. This figure equals the average price difference for West Germany during the total period of estimation.

Just as in section 3.3 we shall first consider a maximum revenue policy and then a minimum budget policy.

3.4.1 *Maximization of total revenue*

In this section those values for the policy instruments are determined which maximize total revenue of butter. The policy instruments considered are:

- price of regular butter: P_1
- price difference between regular and second-grade butter in the Netherlands: P_d^N
- price difference between regular and second-grade butter in West Germany: P_dG

– quantity of 19.08 butter, made available in the Netherlands: $C_{19.08}$
– quantity of butter made available under special arrangements in West Germany: SA

As can be seen from Table 3 (c) the equation for domestic consumption of second-grade butter in the Netherlands (C_2^N) is:

(21) $C_2^N = 49.65 - 27.09P_2^N - 2.44P_d^N$

where P_2^N is the price of second-grade butter in the Netherlands. Because:

$P_2^N = P_1 - P_d^N$. (21) can be written as:

(22) $C_2^N = 49.65 - 27.09P_1 + 24.65P_d^N$

This similarly holds for the consumption of second-grade butter in West Germany (C_2^G):

(23) $C_2^G = 327.85 - 105.20P_1 + 95.13P_d^G - .139SA$

The equation for total consumption of regular butter is:

(24) $C_1 = 1223.04 - 247.17P_1 - .605C_2^N - .564Q_2^N - .532C_{19.08} - .537C_2^G - .468SA$

This equation is the result of adding the demand equation for the four countries; for the United Kingdom and Denmark those from Table 3 (a) for the Netherlands and West Germany those from Table 3 (b).

For the total quantity of available butter and for the export possibilities, the same assumptions are made as in section 3.3. As mentioned already Q_2^N was assumed to be equal to $0.64C_2^N$. With these starting points, the expression for total revenue of butter (R) is:

(25) $R = C_1P_1 + 1.64C_2^N (P_1 - P_d^N) + C_2^G (P_1 - P_d^G) + .55C_{19.08} + .55SA + .96E_1 + PE_2.E_2$

This quantity is to be maximized, subject to the restriction that total quantity sold should not be greater than 1008.1 or:

(26) $C_1 + 1.64C_2^N + C_2^G + C_{19.08} + SA + E_1 + E_2 < 1008.1$

As discussed already, for Q_2^N, $C_{19.08}$ and SA upper limits were set. Further the assumptions about the export possibilities imply that E_1 cannot be greater than 46. The coefficients of the demand equation for C_2^N were such that C_2^N Could easily become negative. In reality this cannot occur, of course, so this was prevented in our problem formulation by the constraint: $C_2^N > 0$. C_1, C_2^N and C_2^G were substituted in equations (25) and (26) and in the expressions (24), (22) and (23). By introducing the constraints mentioned; the maximization problem, after some rearrangement becomes:

$$(27)\ Max\ R = -314.1P_1^2 - 40.4\,(P_d^N)^2 - 95.1\,(P_d^G)^2 + 61.0P_1P_d^N + 149.3P_1P_d^G - .53P_1C_{19.08} - .53P_1SA + .14P_d^GSA + 1408.3P_1 - 81.4P_d^N - 327.8P_d^G + .55C_{19.08} + .55SA + .96E_1 + PE_2E_2$$

With restrictions:

$$314.1P_1 - 16.6P_d^N - 44.1P_d^G - .47C_{19.08} - .47SA - E_1 - E_2 > 354.2$$
$$C_{19.08} < 11.5$$
$$SA < 41.5$$
$$E_1 < 46.0$$
$$P_d^N > .15 \text{ or } C_2^N = 0$$
$$P_d^G > .15 \text{ or } C_2^G = 0$$

This is a quadratic programming problem which was solved by means of the Beale algorithm (see, e.g., Beale, 1967). The resulting values for the policy variables and some further quantities of interest are presented in Table 6. In column A of this table only the price of butter is considered as an instrument. This serves as a control to estimate the effect of the other policy instruments. As was mentioned already, the two values for PE_2, 0.30 and 0 are considered. Further there are two options for the price difference between regular and second-grade butter. In the past these price differences have been different for the Netherlands and West Germany. It can be imagined that within the framework of the Common Market one would like to have these price differences equal. Therefore we calculated optimum values of the policy variables for different and equal price differences. Because it cannot be established that the objective function is concave, there is no certainty that the quadratic programming procedure finds the absolute maximum. Since a grid search applied to column B in Table 6 did not discover a point with a higher value for R, we are confident that the solutions produced by the Beale algorithm are absolute maxima.

From a comparison of column A with the first row of Table 4 it appears that in the case of no additional instruments it makes some difference if one takes the equation for all butter or for regular butter as a starting point. The first was done in section 3.3, which resulted in an optimum butter price of 2.33 Eurs/kg. Here regular butter is taken as a starting point, which gives an optimum price of 2.62. Although the effect of second-grade butter is not explicitly considered in section 3.3, it is implicity assumed that a part of the

Table 6. *Optimum values for policy variables when total revenue of butter is maximized*

	A	B	C	D
	No additional instruments $PE_2 = .30$	$PE_2 = .30$ $P_d^N \neq P_d^G$	$PE_2 = .30$ $P_d^N = P_d^G$	$PE_2 = 0$ $P_d^N \neq P_d^G$
Variable				
P_1	2.62	2.51	2.53	2.35
P_d^N	–	.83	.18	.77
P_d^G	–	.18	.18	.15
$Q_{19.08}$	–	0	0	0
SA	–	0	0	0
E_1	46.0	46.0	46.0	46.0
E_2	387.6	322.1	324.7	273.3
C_1^N	574.5	556.3	557.1	586.1
C_2^N	–	2.0	0	4.9
Q_2^N	–	1.3	0	3.1
C_2^G	–	80.4	80.3	94.7
Total revenue (R)	1667.9	1733.1	1732.9	1630.1

butter consumed is second-grade butter, for which the demand elasticity apparently is somewhat higher than for regular butter. The effect of introducing second-grade butter is explicitly demonstrated when columns B and A of Table 6 are compared. When second-grade butter is available, total revenue increases by about 65 (millions Eurs). Optimum price differences for Germany and the Netherlands are 0.18 and 0.83, respectively.

The effect of the different assumption on export prices can be seen by comparing B with D. With no revenue for exports above the 'normal' quantity, the optimum price (P_1) is 0.16 lower and total revenue decreases with more than 100 million Eurs compared with a marginal export price of 0.30 Eurs/kg.

The results for an equal price difference between regular and second-grade butter for the Netherlands and West Germany are presented in column C. Compared with column B, only the disappearance of second-grade butter consumption in the Netherlands is worthy of mention. According to (22) C_2^N becomes negative, an impossible event in reality. So in (24) C_2^N and also Q_2^N are fixed at zero, which leads to a slightly different expression for the total revenue and the first restriction [(27)]. With a high price level of regular butter, it is impossible to sell second-grade butter in the Netherlands without a substantial price reduction.

Butter under special arrangements ($C_{19.08}$ and SA) should never be made available. This is immediately clear from the coefficients of $C_{19.08}$ and SA in the objective function. Each kg of butter sold in this way replaces about 0.5 kg of regular butter and brings in a direct revenue of only 0.55 Eurs/kg. So in the Netherlands the price of regular butter must be as low as about 1.10 before the sale of this type of butter becomes profitable. For West Germany this price is even lower because SA butter replaces also a small amount of second-grade butter.

3.4.2 *Minimum budget*

The same assumptions as in section 3.3.2 are used for the skimmed milk powder market. Extra elements in the definition of the budget costs are now the price reduction for second-grade butter ($P_d{}^N$ for the Netherlands; $P_d{}^G$ for West Germany) and the quantities of special arrangement butter ($C_{19.08}$ for the Netherlands and SA for West Germany). For these countries the demand equations for all butter are exchanged for regular and second-grade butter demand equations (see Table 3).

Hence the budget equation is as follows:

$$(28)\ B = E_2(P_1 - PE_2) + E_1(P_1 - .96) + SA(P_1 - .55) + C_{19.08}(P_1 - .55) + (C_2^N + Q_2^N)P_d^N + C_2^G.P_d^G + 0.58\{(Q_F + Q_E)(P_s - .36) + (Q_{FA} \div Q_{ST})P_s\}$$

where $E_2 = S - C_1 - C_2{}^N - Q_2{}^N - C_{19.08} - SA - E_1$

All variables are already defined in sections 3.3, 3.3.1, 3.3.2 and 3.4.1, just like the particular values of the constants used.

Written as a function of the instrument and exogenous variables and by using (18), (22), (23) and (24) and the second footnote of Table 5, this expression reads as:

$$(29)\ B = 1023.38 - 841.02P_1 + 49.65P_d{}^N + 327.85P_d{}^G - .55C_{19.08} - .55SA - .96E_1 + 306.58P_1{}^2 + 24.65(P_d{}^N)^2 + 95.13(P_d{}^G)^2 - 36.83P_1.P_d{}^N - 149.25P_1.P_d{}^G - .436P_1.Q_2{}^N + .532P_1.C_{19.08} + .533P_1.SA - .139P_d{}^G.SA + Q_2{}^N.P_d{}^N + PE_2(386.34 - 306.58P_1 + 9.74P_d{}^N + 44.05P_d{}^G + .436Q_2{}^N + .468C_{19.08} + 467SA + E_1)$$

where the expression within brackets is: $-E_2$

The budget costs have to be minimized under the following restrictions:

$E_2 \geq 0$	$SA \leq 41.5$
$P_d^N \geq .15$ or $C_2^N = 0$	$Q_2^N \leq 3.9$
$P_d^G \geq .15$ or $C_2^G = 0$	$E_1 \leq 46$
$C_{19.08} \leq 11.4$	$Q_2^N = .64C_2^N$ if $Q_2^N < 3.9$

It is easily checked by partial differentation of (29) that the optimum values of SA and $C_{19.08}$ are zero if P_1 is greater than $0.77 + 0.26P_d^G$ and 0.77, respectively (under the assumption $PE_2 = .30$). Now differentation of (29) with respect to P_1, P_d^N and P_d^G (within the feasible area) leads to the optimum instrument values. The results are stated in Table 7.

Just as in section 3.4.1 the expression in (29) is an indefinite quadratic form, which means that a local minimum is not necessarily a global minimum. However, after fixing SA and $C_{19.08}$ in (29) equal to zero, the remaining quadratic form is positive definite. Thus, one can be quite sure that the local minima, as given in Table 7, are also global within the feasible area.

As can be seen from the first column of Table 7 and row 1 of Table 5 the two different demand equations give slightly different results for the optimum butter price and the budget. Since the demand equations for all butter incorporate the effects of second-grade butter, which has a more price elastic demand, it is not surprising that the optimum butter price is then slightly lower. A zero level of the additional instruments is a starting point for a judgment of the influence of these instruments on the budget.

The results of the optimization, with a marginal export price of 0.30 Eurs/kg, as shown in the second column, indicate a considerable budget saving effect of introducing second-grade butter (82 million Eurs). The price difference with regular butter is optimum for the restricted value of 0.15 Eurs/kg.

Although a different assumption for the price of extraordinary exports of butter clearly decreases the optimum price of regular butter, still the budget will not increase very much (see the third column). Also here an optimum policy will not sell SA butter on the Netherlands and German market. An optimum policy, for $PE_2 = 0$, places the total quantity of butter in normal export channels (E_1) and on the internal market. So the constraint on E_2 becomes active..

A 10% increase of both the supply of butter and skimmed milk powder

Table 7. *Figures for a budget minimizing policy with instruments: Price of regular butter, price difference between regular and second-grade butter, SA butter*

Variables		$PE_2 = .30$ Zero supply of second-grade and *SA* butter	$PE_2 = .30$ Optimum policy using all instruments	$PE_2 = 0$ Optimum policy using all instruments	$PE_2 = .30$ Optimum policy for a 10% increased supply of butter and skimmed milk powder
Price instruments					
Price of regular butter (P_1)		1.50	1.57	1.44	1.54
Price difference between regular and second-grade butter	West Germany (P_d^G)	–	.15	.15	.15
	the Netherlands (P_d^N)	–	.15	.15	.15
Price of skimmed milk powder		.723	.691	.755	.705
Home market consumption					
Regular butter (C_1)		851	732	754	737
Second-grade butter in West Germany (C_2^G)		–	177	190	180
The Netherlands ($C_2^N + Q_2^N$)		–	15	18	16
Special arrangements butter in					
West Germany (*SA*)		–	–	–	–
The Netherlands ($C_{19.08}$)		–	–	–	–
Export					
Normal (E_1)		46	46	46	46
Extraordinary (E_2)		111	38	0	130
Total revenue of butter		1358	1475	1400	1489
Total budget		498	416	421	657

Prices are in Eurs/kg, consumption and exports in 1000 tons and revenues and budgets in million Eurs.

somewhat lowers the optimum price of regular butter. Although home-market consumption of regular and second-grade butter will slightly increase, most of the extra butter will be sold as extraordinary exports. It is worth mentioning that a 10% increase in supply will raise the budget by 58%. Just as in section 3.3.2 the price of the additional quantity of skimmed milk powder is assumed to be zero. The bulk of the second-grade butter will be consumed in West Germany. Of course, one must remember that these figures are strongly influenced by the not very reliable second-grade butter demand equation of this country. Selling 'special arrangement' butter is not budget saving. Leakages to the regular and second-grade market are here too important.

3.5 *Evaluation of the computed optimum instrument values*

In the optimization procedure, dealt with in the preceding sections, the starting point is a given quantity of butter which has to be allocated over a number of selling possibilities. We assume that all butter supplied has to be disposed of. So the possibility to keep butter in stock hoping that the (uncertain) future will offer more profitable transactions is ignored. As a typical year we chose 1972 as a basis for our computations. We feel, however, that our findings are more generally applicable and might be taken into account also when future policy measures are considered.

Optimization means in our analysis finding the maximum revenue of the butter supplied, and the minimum budget for butter (and skimmed milk powder), respectively. Under the maximum revenue policy, an optimum price of butter is about 2.35–2.60 Eurs/kg, depending on the external price of butter and the use of other instruments. Introducing second-grade butter with a price reduction of about 0.20 and 0.80 Eurs/kg for West Germany and the Netherlands, respectively, increases the total revenue of butter by about 65 million Eurs.

A budget minimizing policy leads to a much lower optimum price of butter, i.e., 1.44–1.57 Eurs/kg. The selling of a considerable amount of second-grade butter at a price reduction of 0.15 Eurs/kg decreases the budget with about 80 million Eurs. Of course, under a budget minimizing policy, the consumer will meet a much lower price and internal consumption is larger than under a maximum revenue policy.

Selling butter under 'special arrangement' as was done in the past is not in harmony with either of the two policy aims. The resulting reduction in the consumption of regular and second-grade butter is too important.

From the results presented in section 3.3.1 it follows that the revenue of butter can be increased when butter prices are allowed to differ in the four countries. Such a policy is in use for the U.K. where a price reduction of butter for the consumer is financed by the British government and the EC-funds (see Memorandum, 1973). Of course also under a minimum budget policy, the budget can be lower when individual countries have different butter prices.

Nearly always, but particularly under a maximum revenue policy, supply exceeds internal consumption together with 'normal' export. This indicates that in the long run it is appropriate to reduce production, also in view of the trend in butter consumption, which is strongly negative. Especially the budget depends on the difference between supply and internal consumption plus 'normal' export.

4. Concluding remarks

The most important results of this study can be summarized in the following points:

- Price elasticity of demand strongly differs between the four countries. Evaluated at 1972 levels of prices, the range of the elasticities is from −0.32 for Denmark to − 3.14 for the non-domestic consumption in the Netherlands.
- Because of these differences in elasticities, statements about an optimum butter policy in the EC cannot be based on the demand functions for a single country or a small number of countries.
- In all countries there is a clear negative trend in the consumption of butter per head which amounts to 3 and 4% (per year) for Denmark and the United Kingdom respectively; 9–11% for West Germany and 10–18% for the Netherlands. The figures for the last two countries depend on the type of butter (namely all or regular butter) and the type of market.
- One kilogram of second-grade butter replaces 0.5 to 0.6 kilogram of regular butter. This proportion is for 'special arrangement' butter 0.45 to 0.55.
- The two different policy aims considered, maximum revenue and minimum budget, resulted in quite different values for the optimum price of butter.
- It always serves the aims of both policies if second-grade butter is available at a reduced price.
- The sale of 'special arrangement' butter as was done in the past will always be sub-optimum.

– The aims of both policies could be fulfilled better by using different instrument values for different countries.
– A minimum budget policy leads to an optimum butter price in the range 1.44–1.57 Eurs/kg. The policy formulation of the EC Commission, as stated in the Memorandum (1973), proposed a butter price of 1.53 Eurs/kg. So, the proposal agrees with our minimum budget policy.

APPENDIX: *Statistical sources*

COUNTRY	VARIABLES	SOURCE
Netherlands,	Butter consumption	N.I.A.M. (via Produktschap voor Zuivel)
(domestic consumption)	Butter prices	N.I.A.M. (via Produktschap voor Zuivel)
	Margarine prices	Centraal Bureau voor de Statistiek (C.B.S.)
Netherlands	Butter consumption	Produktschap voor Zuivel and N.I.A.M.
(non-domestic consumption)	Butter prices	Centraal Bureau voor de Statistiek (C.B.S.)
	Price index for margarine and other fats	Centraal Bureau voor de Statistiek (C.B.S.)
United Kingdom	All consumption and price figures used	Attwood Consumer Panel (via Nederlands Zuivelbureau)
West Germany	All consumption and price figures used	Metzdorf and Schmidt (1972, 1973)
	Price index of food	*Agrarwirtschaft*, several volumes
Denmark	Consumption figures and producer prices	*Danmark Statistik, Statistiske Efterretninger*, several volumes
	Retail prices	*Danmark Statistik, Detailpriser*, several volumes
France	Consumption of butter	Ministère de l'Agriculture
	Butter prices	INSEE, Indices de prix de detail, Enquête alimentaire permanente
Italy	All figures	Institutio Nazionale di Ecònomia Agraria. (figures personally provided by Dr. F. Majnoni)
Belgium + Luxembourg	Consumption of butter and producer prices	Landbouw-Economisch Instituut and Nationale Zuiveldienst
	Retail prices	Ministère des Affaires Economiques et de l'Energie
Ireland	All figures	Central Statistics Office, Dublin
All countries	Number of inhabitants	Monthly Statistics of the EC 8/1973
	Exchange rates	

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