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SPECIAL ISSUE

Milk Quotas

edited by

Jean Marc Boussard
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Introduction

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The creation of milk production quotas,\(^1\) initiated by the E.C. council of ministers in April 1984, was rather a surprise for most European agricultural economists, just as, some years before, was the institution of the Monetary Compensatory Amounts (MCA). In both cases, the decision was purely political, and taken under the pressure of necessity: MCA's because of the necessity of devaluating a weak franc without providing too large a gift to French farmers, milk quotas to limit the development of budgetary expenses without decreasing farm incomes too much. In both cases, also, an ingenious institutional mechanism was set up, which had the advantage of immediately solving a cumbersome political problem, and the drawback of creating a number of future difficulties. The latter are now more or less clearly delineated with respect to the MCA's (Ritson and Tangermann, 1979) and are probably still unknown as far as milk quotas are concerned.

Insofar as production economists are more concerned, in general, with the long than the short run, it is not surprising that few of them had anticipated the kind of solution put into effect by politicians in these circumstances.\(^2\) They were advocating simpler and more classical solutions, involving, for instance, a price decrease, to be eventually compensated by direct subsidies. But once the decision for installing quotas had been taken, they felt themselves compelled to examine its consequences.

There is an urgent need for an evaluation of the milk quota policy. A first and obvious reason is that, each year, decisions must be taken with respect to price and quota levels. A second, and more important one, is that, if the quota policy proves to be detrimental, it is easier to change it immediately than after several years have elapsed; and if it proves to be beneficial, it could be wise to generalize it to other commodities, and the sooner the better. In that context, imperfect and eventually contradictory assessments may be valuable, provided that they are immediately available. It is the purpose of this special issue of the ERAE to supply such imperfect readily available evaluations.
The assessments are imperfect in two ways: first, because the consequences of milk quotas are innumerable. Only a few of them could be investigated in a limited time (the decision to prepare this issue was taken in September 1984, during the meeting of the European Association of Agricultural Economists in Kiel). Second, because the various econometric models used in this exercise were built for other purposes. We shall examine these two points successively.

The quota policy issues

The existence of milk quotas will obviously modify the behaviour of farmers. First, they will have to find a way for reducing milk production — by reducing the number of cows, or by reducing the yield of each cow, or both. Second, they will have to re-use the fixed production factors which will become available from the reduction in milk production on other crop or livestock enterprises. In that respect, though the pure micro-economics of quotas, as perfectly expressed, for instance, by Harvey and Hubbard (1984), is already well known, there are still open questions, some of them evoked by contributors to this issue. For instance, from a purely theoretical standpoint, Burrell examines a possibly important side effect of quotas, or, rather, of their implementation through the so-called ‘Formula B’. Some words of explanation are necessary here. The EC Commission presented the member governments with the choice between two ‘formulas’ for implementing quotas. Under ‘Formula A’, quotas are attributed to each producer individually. This is the classical textbook scheme of production quotas. Under Formula B, they are given to ‘dairies’ (and, even, to ‘groups of dairies’), instead of to producers. This means that some individual producers may be allowed to produce much more than under Formula A, if, on the other hand, some others decide to produce much less. Since it is likely that each year, a certain number of farmers will stop to produce milk for various reasons (retirement or even inducement, as was the case in France, for instance), Formula B seems to provide more flexibility than Formula A. For this reason, it has been chosen by the majority of member states.

However, and this is the point raised by Burrell, Formula B may generate side effects, by introducing an element of uncertainty into the decision of producing milk: the position of each dairy with respect to its quota cannot be known before the end of each year. Before that, no farmer knows whether his dairy will or will not be an over-producer, and, therefore, whether he will be paid the full or reduced price. Using the theory of the decision-maker under uncertainty, she shows that this situation can lead to more or less cyclical behaviour in milk production, with all the associated detrimental (and, eventually beneficial) consequences of such cycles.

From an empirical point of view, several papers throw unusual light on the determinism of the choice between reducing the number of cows, or reducing the yield of each cow. Rasmussen and Nielsen, using data from actual Danish
farms, show that one of the main determinants of the solution is the opportunity cost of labour: a high cost of labour means that a high proportion of the adjustment should be made by a reduction in the number of cows, and vice versa. Thus, one of the most important effects of milk quotas is dependent upon the general situation on the employment market, a conclusion which was certainly not taken into consideration when the decision to adopt formula B was made. Similarly, van der Giessen and Post provide some evidence of the actual behaviour of Dutch farmers, who will probably choose to reduce the number of cows. Other papers reach analogous conclusions.

Finally, the consequences of milk quotas on non-milk agricultural enterprises are examined in several papers. For instance, Munk develops a model of the agricultural sector at the Community level in the spirit of general equilibrium, taking into consideration agricultural demand for inputs, as well as agricultural supply of all kinds of commodities, and equalizing prices to full costs. In this framework, a quota lowering milk production by 5% increases the supply of most agricultural commodities by 1.3%, and decreases the demand for agricultural inputs by various amounts, ranging from 2.2% for feedstuffs to 0.4% for fertilizers. It is shown that a milk quota of 5% has the same effect on production and agricultural income as a decrease in the milk price of 7.2% combined with a lump-sum payment corresponding to 2.6% of the value added. The model is also used to forecast the evolution in agricultural production and income over a five year period. Based on assumptions about changes of productivity and changes in the primary factors of production, taking account of the 5% milk quota and assuming a 10% decrease in cereals prices with other prices held constant in real terms, the model forecasts that cereal production will go up by 7.2%. The results of the model should not be taken too seriously since, as emphasized by the author, they are based on parameter values which are merely illustrative. The results are interesting mainly as indicators of the potential importance of taking into account the effect of policy measures directed towards one item on all outputs and inputs.

Farmers' reactions are not the only problems raised by the institution of milk quotas in the EC. Their consequences on other economic agents have to be examined. This is the purpose of most of the contributors to this issue. Thus, Thomson and Hubbard evaluate the consequences of milk quotas on other commodities, using already estimated cross elasticities, and the effects these have on international trade patterns at the community level. Quotas are shown to reduce the burden of the taxpayer, but costs for milk producers, as well as for processors, are important. The cost of FEOGA expenditures on the cereal sector is increased, but less than the reduction in expenditures on the milk sector. It is interesting to note that the absolute real values of these costs are not decreased: the reduction, here, is only relative to the estimated amount of expenditures in the situation without quotas (in other words, quotas do not decrease the FEOGA expenditures, but prevent them from increasing).

Cioffi et al. stress the consequences of quotas in the particular case of Italy.
This country occupies a specific place in the EC milk market, as the main net importer. In addition, this situation may be viewed as a consequence of the EC, since there is at least a coincidence between the date at which it began to occur, and the integration of the Italian economy into the EC. In fact, the Italian milk deficit is a consequence of the upsurge of consumer demand generated by a rise in income and changes in preferences which may have been triggered by the integration. It is therefore interesting to investigate the possible consequences of quotas on consumer demand. The conclusion is that consumption is less responsive to price than supply, with the consequence that quotas do not reduce consumption but increase supply compared with an alternative in which price is decreased.

Three papers are concerned with intermediate links in the chain between producers and consumers. Ioannidis considers the size and composition of the cattle stock. This point is obviously important, since a possible side effect of the milk policy is that it causes disturbances in the meat market. In addition, such disturbances, if detrimental, may be difficult to correct in the short run, because of the demographic determinism of meat supply. In effect, a cyclical behaviour of the main variables associated with the characteristics of the EC bovine herd can be seen in the figures provided. On the whole, the conclusion is that a quota, or a reduction in milk price (the two policies are not differentiated) could substantially reduce the supply of meat (by 2-2% of its present level). Although some of the conclusions of Ioannidis may be surprising (the increase in male cattle following the introduction of quotas), his study seemed sufficiently interesting to be included in this issue.

Bingley, Burton and Strak investigate the consequences of quotas at the level of the milk industry, i.e. they do not consider farmers only, or consumers only, but the whole chain from producers (and their feedstuffs suppliers) to consumers. Their analysis is restricted to the United Kingdom. One important consequence of their simulations is that the milk quotas could significantly lower the demand for cereal feedstuffs, and consequently, simply transfer the problem of surpluses from milk to cereals. This is a conclusion also stressed by Thomson and Hubbard, as well as by Munk, using quite different modes of analysis.

Similarly, Oskam's contribution is directed toward the examination of effects of quotas on producers, consumers, and E.C. budget, using a previously built model of the EC dairy subsector. He shows that, according to expectations, quotas give a rapid decrease of budget costs, a higher farm income, and are detrimental to consumers. From a welfare point of view, a decrease in the milk price, compensated by income allowances for farmers, would have been preferable. In any case, the delays which occurred between the observation of overproduction, and the decision to correct it, were costly: if the corrective measures had been taken in 1977 instead of in 1984, the burden of any policy for the taxpayer would have been significantly reduced. Unfortunately, his model was not designed to include a study of the cross effects of milk quotas on the production of other commodities (such as grain, for instance).
Finally, it may be interesting to try to evaluate the consequences of quotas at the level of the economy as a whole, and not only from a partial equilibrium point of view. This is the aim of van der Giessen and Post, in the second part of their contribution. They describe the induced effects of quotas on the Dutch economy, assuming that all prices are constant, and that there is no substitutability between factors in all branches of production. In this way, their model may be considered as a generalisation of the Keynesian multiplier of consumer expenditures. It probably overestimates the shrinking effect of quotas over the national income. But even keeping possible overestimation in mind, the figures they display are impressive: for instance, farm investment in buildings may decrease by 40%, and other farm investments by 30%. Obviously, this raises some serious questions.

In addition, two sided (but not unimportant) questions are tackled in this issue. The first is the reason for the choice of a quota rather than a price policy for decreasing milk production. Clearly, the utility function of the decision-maker is at stake here. The original contribution by Burton aims at revealing the preferences of the Council of Ministers. It is therefore a political science paper, rather than one of economics. This is not to say that economic analysis is absent from the model. On the contrary, it is essential for a precise assessment of the coefficients of the Council's objective function. It is not surprising to find that budgetary expenditures play a large (and perhaps exaggerated) role in this objective function.

The second of these questions is the observed effect of quotas. In effect, production quotas are not a completely new experience for agricultural economists. They have been in operation for a long time, and not without success, in the sugar beet subsector. Several articles on sugar quotas have been published during the past few years in this review (Koester and Schmitz, 1982) or elsewhere (Smith, 1980). It is only necessary to recall them. Even for milk, quotas were instituted some years ago in Canada and in Switzerland. If fortuitous contingencies did not permit the inclusion in this issue of a paper on the Canadian experience with milk quotas, the reader will find here an account of the Swiss situation after five years. Peter Rieder shows that quotas in Switzerland did not significantly decrease production, nor federal budgetary expenses, essentially because the farmers' political power is so great that they managed to escape the quota constraint, and to obtain higher prices.

A certain consensus emerges from this review. Actually, convergences are more marked than was expected by the initiators of this special issue. The decision to impose quotas was made in order to decrease the budget cost of the milk common policy. In that respect, it was certainly successful. But this goal has been achieved at the expense of consumers (because of higher prices), and to a certain extent, of the suppliers of agricultural inputs. The side effects are important, and will create problems for the grain sector in the next few years. The effects on the meat sector are more ambiguous, and it is difficult to assess them precisely.
in the present state of economic science. It will probably depend upon the
development of variables which are completely outside the agricultural sector.
The employment effects of the quota policy are probably negative, mainly
because of its depressing consequences on the feedstuff industry.

None of the contributions presented here address themselves to the question
of the consequences of quotas on land prices and agricultural structures, although
these are probably significant, and crucially dependant upon apparently second­
ary details of application of the quota policy. For example, by increasing agricul­
tural incomes, quotas are likely to raise the price of land, but this increase
may be small if the right to produce is detached from land ownership, and other­
wise may be quite significant. There is here a field for further research, which
should involve new models, with more dynamics and fewer comparative statics.

Similarly, the seasonality of production is ignored in all models and analyses
presented here, although it is obviously an important dimension to be considered
(will the reduction in production take place in summer, in winter, or in both?)
Many recent developments of the EC quota policy are not studied, in particular
the geographical effects of the 'nationalisation' of quotas in some of the
Member states which have chosen the 'B formula'.

The possibility of mobilizing a large number of econometric models in a
relatively short time for the study of very practical and very complex policy
issues has been demonstrated. This should be the task of government agencies
rather than of academic institutions or of professional associations. It is to be
hoped that this lesson will be retained by officials. Making a more extensive use
of this facility would greatly help in the achievement of a sounder and more
efficient policy, even if knowing the effects of a policy change is a necessary, but
not sufficient, condition for that. The question here is that of the credibility of
the various models used in this exercise. We shall now turn our attention to this
problem.

The econometrics of quotas

Most of the conclusions presented above rely on econometric models which were
not designed for the purpose of examining the issues at stake. This may be an
advantage, since they will not be under suspicion of having been built in order to
defend a particular thesis. At the same time, it may be difficult to have confi­
dence in the conclusions of models estimated in a context very different from
that in which they are used here. This remark does not apply to all of them:
linear programming models, or models derived from input/output tables, such
as those of Munk or of van der Giessen and Post, are not subject to this kind of
reservation and quotas can be introduced very naturally, as an additional con­
straint, to which a shadow price is attached. This is not to say that these models
are perfect in predicting reality, but their imperfections are not increased by the
fact that they are used in a different context. On the contrary, with models
depending upon statistical inference over past data, the question of the reliability of estimates arises: since the data reflect a situation 'without quotas', would they have led to the same values of parameters in the situation 'with quotas'? The answer is 'yes' — with some reservations — provided that these models are based on sound economic analysis. Since this question is important not only for the conclusions stated above, but also, in the context of the EC agricultural policy, for a number of practitioners in applied econometrics, we shall elaborate a little on this point.

Statistical inference can be used at different levels for predictive purpose. A first level consists in simple extrapolation through time: if past observation shows that there is a good correlation between the supply of milk and, say, the price of wheat, and if no change occurs in the general context of milk production, and of wheat price development, then it may be sound to predict the former from the value of the latter. But, of course, any change in context will probably change the value of the correlation coefficient, thus making the prediction false. This is obviously the case with the institution of quotas.

The situation is quite different at the second level, where statistical inference is used to estimate unknown, but technologically and economically significant coefficients. Suppose economic theory is correct when assuming farmers are maximizing their global profit, \( pq - xy \), where \( p \) and \( x \) are row vectors of output and input prices respectively, whereas \( q \) and \( y \) are the corresponding quantity column vectors, under a production function constraint, \( f(q, y, \theta) = 0 \), where \( f \) is a prespecified function relating outputs \( q \) to inputs \( y \) when a vector \( \theta \) of parameters is given. From these assumptions, and if some additional conditions pertaining to \( f \) are fulfilled, it is possible to define \( \hat{q} \) and \( \hat{y} \), the predicted values of \( q \) and \( y \), as functions of \( \theta \), \( p \), and \( x \). Comparing, then, \( \hat{q} \) and \( \hat{y} \) with actual observed values \( q^* \) and \( y^* \), it is possible to choose \( \theta \) so as to minimize some distance between \( (\hat{q}, \hat{y}) \) and \( (q^*, y^*) \). This is the essence of statistical inference applied to the estimation of production models.

In that context, \( \theta \) is only a characteristic of the existing technology, and should not, therefore, be affected by the existence of quotas. If a quota, or any other additional constraint, is added to the farmers' problem, there is no need, in principle, to re-estimate \( \theta \). It is only necessary to rewrite the model, and the associated computer programs, keeping the previous value of \( \theta \) as given. In that way, the statistical (and most difficult) task of setting up a model can be avoided, in principle without loss of reliability.

A special case of this reasoning arises when a statistically estimated equation includes the price of milk as an explanatory variable of production. In this situation, various theorems on the separability of models show that levels of production can be computed using a shadow price of milk. The latter can be determined by the condition that, with this price of milk, the milk production exactly equals the value of the quota. This argument is developed in some articles of this issue, especially by Ioannidis. On the other hand, the actual price
of milk is used for computing income values, and, eventually, the levels of risk and liquidity constraints, whenever they are present.

Unfortunately, the preceding reasoning is not completely valid, because, in practice, misspecifications of the production function $f$ make the values of $\theta$ more or less dependent on the estimation context: the analytical form of $f$ may not reflect the true technical relationships between $x$ and $y$, or other constraints (such as, for instance, risk or liquidity constraints) may have been forgotten in the specification of the original model, or the dynamic consideration, involving the effect of year to year benefits on agricultural structures, may have been neglected. In such cases, $\theta$ will not only reflect technical considerations, it will also be dependent upon spurious correlations between endogenous and exogenous variables, just as in the case of what we called level one of statistical inference, above. For instance, when using the shadow price technique, the computed value of the shadow price should account for the opportunity cost of additional income, in terms of the usefulness of saving for additional investments. If saving and investment functions are absent in the model, the estimated coefficients will be biased, because they will incorporate both the 'true' relationship between price and production (independently of income) and also the hidden impact of the utility of high prices for saving. In that case, the shadow price of milk will be incorrectly computed, and therefore, the prediction pertaining to production will be erroneous. Thus, in such situations, a model can still give 'good' (in terms of adequacy between predicted and observed values) results as long as the general context does not change too quickly, but it can perform very badly if this general context is modified.

This is why the models estimated in a situation 'without quotas' cannot be used without reserve in a situation 'with quotas'. The discrepancy between results and reality, in that case, will be directly related to the importance of the misspecifications just described, and to that of the modification of the 'context'. But even with such reservations, they are not completely without value, insofar as the role played by spurious correlations is reduced. Here is the basic reason for having a limited, but real confidence in the results which are presented in the following papers. The contributors, as well as the members of the editorial board, are well aware of the limitations of the papers published here. They felt nevertheless that these contributions, partial as they are, could be more useful to readers now than presented as more extensive studies later on.

NOTES

1. Strictly speaking, the word 'quota' is wrong: the law does not prevent any citizen of the E.C. from producing as much milk as he wants. But selling any quantity of milk in excess of the allowed ceiling is submitted to a 'super levy', the rate of which is such that the remaining revenue is practically null. Economically, therefore, this regulation is the perfect equivalent of a quota.
2. This is not completely true, however: quotas have long been envisaged in pure theory as a means of solving the difficult problem of market stabilisation when the supply is subject to random shocks, see for instance Hazell and Scandizzo (1977). The context was nevertheless somewhat different. In addition, scattered studies and working groups recently mentioned quotas among the possible solutions of the EC milk problem, for instance Oskam (1981) or Henze and Zeddies (1979). Often, this mention of quotas is accompanied with the idea that they should be avoided. On this point, the best example is paragraph 11 of the ‘Sienna Memorandum’ (Barbero et al., 1984), which reflects widely shared opinions.

3. See, however, Arcus (1978); Barichello (1981); Albon (1979); van Kooten and Spriggs (1984).

4. That is to say, the whole country is considered as only one 'dairy' for the computation of the excess supply. In that case, there is a possibility of virtually avoiding any super levy for individual producers, the quota policy reducing itself to a mere slight decrease in price.

REFERENCES


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Price uncertainty under EC milk quotas

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Summary

The current arrangements for applying the super levy under the Formula B option introduce a new element of price uncertainty into milk production decisions. In these circumstances it may be rational for individual producers to exceed their quota. Cyclical fluctuations in aggregate supply could develop, with implications for the efficiency of resource allocation and current dairy policy.

1. Introduction

In April 1984 a scheme of milk quotas backed by a 'super levy' on over-quota production was imposed on EC dairy producers. This paper examines a particular feature of the new scheme arising from the Formula B method of assessing the super levy. Under Formula B, the size of the super levy depends on the ratio of annual net excess production to annual gross excess production for the whole dairy, as will be shown more fully below. However, since this ratio is not known until the end of the milk year, price at the margin for producers operating at or above their quota level is now a random variable.

The scheme has therefore introduced an extra element of uncertainty into dairy producer decision-making. Moreover, whatever yield uncertainty is normally present is now more of a problem for those aiming to keep within quota, because the size of the penalty for unplanned over-quota production is itself uncertain. Some short-run fluctuations in yield can be stabilised by producers (although the costs of doing so may not be negligible) whilst others are beyond all control, including that of the policy-maker. In either case, they fall outside

* The author gratefully acknowledges the many helpful suggestions and comments received from Allan Buckwell during the preparation of this paper.
the scope of this paper which is to examine the additional uncertainty provoked by a specific policy instrument. Therefore, yield and price uncertainty are separated and the analysis focuses on the effects of the levy-induced price uncertainty alone.

Whether or not the individual's marginal production bears the levy depends on whether he is over quota. Therefore, assuming controllable yield, the individual producer may choose to operate under conditions of price certainty by deciding to operate within his quota. In this paper, it is demonstrated that for many producers, this may not be the optimal choice. However, for producers who decide to operate above their quota, the size of the levy itself depends on the collective behaviour of other producers and is not known *ex ante*. Individual producers are likely to have simple subjective probability distributions for the current year's levy and moreover, these perceived probabilities will change during the year as information becomes available about the cumulative aggregate position relative to aggregate quota. Hence there may be an important short-term dynamic aspect to decisions about production flows.

The quota literature is unhelpful on the whole question of penalties for quota infringement and appears not to contain any systematic analysis of a quota scheme with stochastic penalties. By contrast, those authors who do consider the implications for price uncertainty of quota schemes involving acreage or volume restrictions alone argue that like other supply management programmes generally, quotas should in fact reduce price uncertainty (Just et al., 1982) thereby leading to a rightward shift of the supply curve and the theoretical possibility of a net welfare gain from quotas (Schmitz, 1983; Moschini, 1984).

Regarding the present EC milk quota scheme, it is difficult to find an economic justification for building this element of uncertainty into the Formula B arrangements. The aim of this paper is to tease out the implications of this feature of the scheme as they affect rational decision-making by milk producers and to comment on the possible consequences for the efficiency of both dairy policy itself and resource allocation in the dairy sector, over and above the efficiency effects of volume control *per se*. Both theoretical models and less formal economic reasoning are used to derive a set of hypotheses for future investigation, when data becomes available, concerning producers' reactions to this additional uncertainty and their implications for milk supply.

### 2. The regulations and notation

The Formula B arrangements analysed in this paper are as follows: each dairy is allocated a reference quantity of milk that it may purchase in a twelve-month period. To implement the scheme, the dairy in turn allocates sales quotas to each of its producers. Milk purchased by the dairy in excess of its reference quantity is liable to the so-called 'super levy'. If total deliveries to a dairy exceed its reference quantity and hence a levy is payable, the dairy will pass back the levy
to individual producers in proportion to each individual's contribution to excess production.

Initially, all EC member states except West Germany, Belgium, the Netherlands and, within the UK, Northern Ireland, opted to apply the super levy at dairy level (Formula B) rather than at producer level (Formula A) (EC Commission, 1984). The Milk Marketing Board for England and Wales, as sole purchasing dairy in these two countries, is allocated what is effectively a national quota. Single national purchaser arrangements also apply in Denmark, Greece and Eire (Agra Europe, 1984). An amendment to EC regulations in February 1985 permitted all EC countries to operate Formula B at the national level for 1984/85. Should this be continued in future years, it must increase the interest and relevance of the questions pursued in this paper.

Let \( x_i \) denote the over-quota production of the \( i \)-th producer who over-produces, i.e.

\[ x_i = y_i - q_i \]

for \( y_i > q_i \)

where \( y_i \) is his actual production and \( q_i \) is his quota.

Let \( d_j \) denote the deficit of the \( j \)-th producer who under-produces, i.e.

\[ d_j = q_j - y_j \]

for \( y_j > q_j \).

The volumes of over- and under-production for the dairy are:

\[ X = \sum_i x_i, \quad D = \sum_j d_j. \]

The net over-quota production of the dairy is then \( X - D \). The total levy payable by the dairy is \( T(X - D) \) where \( T \) is the current target price. The rate of levy per litre of gross excess milk productions is \( T(X - D)/X = T(1 - D/X) \) for \( X > D \) and the contribution of the \( i \)-th excess producer to the levy payment is:

\[ (x_i/X) \cdot T(X-D). \]

The net price received by the \( i \)-th over-producer for each litre of his over-quota output is then

\[ p_i = T(1 - D/X) = p_i - tT \]

where \( t = 1 - D/X \) is the proportion of target price levied and \( p_i \) is his average pre-levy price, allowing for seasonality and quality. In general, we expect \( p_i < T \), whereas \( t \) takes the following values:

- for \( X > D > 0, \quad 1 > t > 0 \).

That is, some gross over-production is offset by the aggregate deficit of under-producers, and over-producers pay a levy of less than 100% of target price.
for $X > D = 0$, $t = 1$.

When no individual producers are in deficit, over-producers pay a levy on over-quota production equal to 100% of target price.

finally, for $X < D$, $t = 0$.

In this case, the dairy as a whole is not in excess of its quota and there is therefore no levy payment to pass on to individual over-producers.

The rate of levy is not known until the end of the production year. Thus the decisions determining a producer's annual output (including herd size and variable input use) depend partly on the expected rate of levy.

Let $p_i^*$ denote the price received by the $i$-th producer for his marginal litre of milk. If he is within his quota, $p_i^* = p_i$. If he is above quota, $p_i^* = p_i - tT$ and $E(p_i^*) = p_i - E(t)T$, where $E(\cdot)$ denotes the mathematical expectation of a random variable.

3. Output decisions in the medium term

The imposition of dairy quotas has given rise to much discussion about the most cost-efficient dairying system for producing at lower output levels. The choice is often summarised as being between cutting herd size and maintaining feeding levels and stocking rates, or maintaining herd size and reducing yields by the least-cost combination of feeding and stocking regimes. In practice, the optimal adjustment for a particular producer may involve changes in all these variables (see Wilson and Lawrence, 1984; Sargent, 1984; Richardson, 1985, for partial budgeting analyses of some of these options). The somewhat conflicting evidence from the studies quoted suggests that the best system for a particular producer will depend on the fixed resources available to him and their productivity in other uses, and will not be the same for all farms. Moreover, it seems that, given current relative prices, no single system dominates over the range of output between pre-quota and quota levels.

The following analysis assumes that whatever short- and medium-term changes to the farming system are required to produce output $y$ at minimum cost are identified and exploited by the producer. In Figure 1, $c(y)$ represents the medium-term envelope of short-run cost curves (such as $c_1, c_2$) along each of which decisions about herd size, grassland management and stocking rates are held constant. For analytical convenience, it is assumed that only feeding rates are adjusted in the short term. Plant, equipment and management are assumed fixed even in the medium term. Thus the medium term referred to here can be thought of roughly as a production year.

Typically, the most efficient adjustment from the pre-quota level, $y^0$, to the quota level, $q$, involves a change in farming system, as shown in Figure 1. By assumption, the individual producer is aware of this and therefore his planned adjustment can be described as a move back down $c(y)$ rather than down $c_1$ or any of the other short-run alternatives. This assumption removes the need to
specify here the farming systems implicit in this cost function and permits the analysis to focus instead on the producer's output decision, given his uncertainty about the levy.

The principal strategies open to the producer are:

1. Adjustment to quota. The producer plans to produce his allotted quota.
2. Adjustment to planned over-quota production. This option allows for output levels in excess of quota and includes as a special case the option of continuing to produce at the pre-quota level.

A pay-off matrix showing the conditional profit levels association with these two strategies is as follows:

<table>
<thead>
<tr>
<th>Strategy:</th>
<th>Dairy: $X &lt; D$</th>
<th>$X &gt; D &gt; 0$</th>
<th>$X &gt; D = 0$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adjust to quota</td>
<td>$pq - c(q)$</td>
<td>$pq - c(q)$</td>
<td>$pq - c(q)$</td>
</tr>
<tr>
<td>Adjust to over-quota</td>
<td>$p^*(q + x)$</td>
<td>$p^*(q + x)$</td>
<td>$p^*(q + x) - Tx$</td>
</tr>
<tr>
<td>Super levy:</td>
<td>$0%$</td>
<td>$1 - 99%$</td>
<td>$100%$</td>
</tr>
</tbody>
</table>

<table>
<thead>
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</tr>
</thead>
<tbody>
<tr>
<td>Adjust to quota</td>
<td>$pq - c(q)$</td>
<td>$pq - c(q)$</td>
<td>$pq - c(q)$</td>
</tr>
<tr>
<td>Adjust to over-quota</td>
<td>$p^*(q + x)$</td>
<td>$p^*(q + x)$</td>
<td>$p^*(q + x) - Tx$</td>
</tr>
<tr>
<td>Dairy:</td>
<td>$X &lt; D$</td>
<td>$X &gt; D &gt; 0$</td>
<td>$X &gt; D = 0$</td>
</tr>
<tr>
<td>Super levy:</td>
<td>$0%$</td>
<td>$1 - 99%$</td>
<td>$100%$</td>
</tr>
</tbody>
</table>
Denoting the entry in the $i$-th row and the $j$-th column of this matrix by $m_{ij}$, it holds that $m_{21} > m_{22} > m_{23}$.

$m_{21} > m_{11}$, providing the marginal cost of $x$ is less than its marginal revenue $px$. The fact that, prior to the imposition of quotas, producers chose to produce beyond quota level supports this assumption.

$m_{22} > m_{12}$, providing the extra revenue earned by $x = (p - t)\pi$ is greater than the cost of producing $x$. At average 1984/5 UK values of $T$ and $p$ and assuming that the marginal cost per litre of over-quota milk is in the region of 9 pence (see Section 4), this condition will be met as long as the super-levy is less than 33% of target price. This in turn requires that the gross deficit production for the dairy is more than 67% of the gross excess production.

$m_{13} > m_{23}$ since $T$ is greater than $p$.

Given the above inequalities, the maximin strategy is to adjust to the quota level of production. One could expect the most risk-averse producers to choose this strategy. So too will those who use a lexicographic approach to uncertain decision-making (Anderson, 1979), giving first priority to avoiding the levy regardless, and only seeking to maximize profit once this priority is met. In effect, both these groups choose a strategy under which price is certain and thus opt out of risk altogether.

Assuming that the other producers are expected to be utility maximizers, with utility defined over profit, following Baron (1970) and MacLaren (1983), the first-order condition for a maximum is given by

$$E(p^*) - c'(y) = R$$

where $R = -\text{cov}(U'(\pi), \hat{p}^*) / E(U'(\pi))$ \hspace{1cm} (1)

For a risk neutral producer, $R = 0$ and $E(p^*) = c'(y)$ at the optimum.

For a risk averse producer, $R > 0$ and $E(p^*) > c'(y)$, whereas for a risk seeking producer, $R < 0$ and $E(p^*) < c'(y)$ at the optimum.

Figure 2 illustrates the way in which the optimum level of output for a utility-maximizing producer under these conditions depends on his attitude to risk and his subjective probability distribution for $p^*$. Up to $q$, the slope of the total revenue curve is $p$. Beyond $q$, price at the margin is a random variable, the curve becomes the expected total revenue curve, and its slope is $E(p^*)$. This slope may be anywhere between $p - T (< 0)$ (for a producer who attaches a probability of one to a levy of 100% of target price), and $p$ (when he attaches a probability of one to there being no levy on excess production). At $y^0$, the pre-quota output level, $c'(y^0) = p$. At quota level $q$, $p > c'(q)$. If $p = c'(q)$, this means that marginal cost is constant over the range $q$ to $y^0$. Whether or not this is so is an empirical question. As the partial budgeting evidence is inconclusive, we assume the more general case of rising marginal cost.

If, as expected, $p > c'(q)$, the producer is out of equilibrium at $q$ and profit maximization is frustrated. Moreover, if he was already a marginal producer, the
cut-back to quota may involve long-term non-viability. In either case, he will certainly consider the relative profitability of output levels in excess of $q$.

For a risk-neutral producer, as long as $E(p^*) > c'(q)$ (for $y > q$), expected utility maximization results in a rational decision to exceed quota. The equilibrium planned output for this producer is shown as $(q + x)$ in Figure 2.

A moderately risk-averse producer (i.e. one for whom $R < 0$ but who is not sufficiently risk averse to adopt a maximin strategy) will plan to exceed quota if $E(p^*) - R > c'(q)$ (Figure 3) and a risk-seeking producer may plan to exceed quota even when $E(p^*) < c'(q)$ (not shown).

This section has shown that, under Formula B, a rational milk producer may plan to exceed his quota, given appropriate combinations of subjective probabilities and attitudes to risk. Although the argument has been illustrated in terms of the adjustment from a pre-quota level of output, it applies equally to subsequent production decisions under a permanent quota regime.

4. The probability distribution of $p^*$

In this section, the uncertainty of the marginal price for over-quota milk is explored and illustrated with a simple probability distribution.
Since \( p^* = p - tT \), and \( p \) and \( T \) are known constants, the first two moments of \( p^* \) are:

\[
E(p^*) = p - E(t) T, \quad \text{and} \quad V(p^*) = T^2 V(t).
\]

Clearly the uncertainty in price derives from the rate of levy and this is probably how farmers themselves perceive the uncertainty. Indeed, it will be \( t \), rather than \( p^* \), that they try to predict. A simple representation of the type of subjective probability distribution farmers may use is

\[
Pr(t = 1) = m \quad (100\% \text{ levy})
\]

\[
Pr(t = 0) = n \quad (no \text{ levy})
\]

\[
Pr(0 < t < 1) = 1 - (m + n),
\]

with \( Pr(t < t^*) = \int_0^{t^*} \left[ 1 - (m + n) \right] dt \)

for \( 0 < t < 1 \) (levy somewhere between 0% and 100%) \( 0 < m, n < 1 \)
That is, producers are assumed to attach subjective probabilities to levies of 0% and 100%, and to the range in between, with the distribution of $t$ between these two limits perceived as uniform. The mean and variance for this assumed distribution are

$$E(t) = (1 + m - n)/2,$$

$$V(t) = (2m + 2n + 1)/12 - [(m - n)/2]^2.$$

Subjective probabilities may vary widely among producers. However, the probability they attach to a levy of 100% is likely to be very small, probably zero, once it is understood that this will happen only if there are no deficit producers in the dairy. On the other hand, the way producers form subjective probabilities for values of the levy between 0% and 100% will depend on the information available to them.

Table 1 demonstrates that there is no functional relationship between the size of net aggregate over-quota production (either measured in litres or as a percentage of quota) and the rate of levy. The figures relate to a hypothetical dairy with a quota of 2,000 million litres. It is shown that, depending on the ratio of net to gross excess production for the dairy, a net excess of 50 million litres (2.5% of quota) is consistent with a levy ranging from 100% to 5% (and less, although as the table reveals, these low rates of levy imply unrealistic magnitudes of over- and under-production). Clearly, even if net annual over-quota production can be accurately forecast from aggregate production figures, it is more difficult to predict the associated rate of levy.

In 1984/5, the Milk Marketing Boards in the UK provided farmers with monthly updates on the size of their Board's net cumulative deficit as a percentage of cumulative quota (the figure for which was not revealed), but there was
no systematic provision of information on gross excess \(X\) and gross deficit \(D\). Yet unless this information is available during the year, with respect to cumulative monthly targets, producers will have difficulty in a surplus year in revising their subjective probabilities in a rational way and so the assumption that \(t\) has a rectangular subjective distribution would then still be quite realistic.

As the subjective probabilities \(m\) and \(n\) change during the year, so too will the expected rate of levy and its perceived riskiness \(E(t)\) may rise or fall, depending on how cumulative aggregate production, relative to cumulative monthly targets, evolves over the months. The individual's perception of \(V(t)\) will probably become smaller: as other producers' intentions become clearer and the end of the production year draws closer subjective probability distributions of \(t\) will probably become more concentrated. The range of values for \(t\) believed possible may also shrink although, as Table 1 illustrates, if \(n < 1\), if cumulative aggregate production is even only slightly above its interim target and if information on \(X\) and \(D\) is not available, it would not be rational to lower the upper bound of possible values for \(t\) (although it would be more realistic to assume a distribution with more density towards lower values of \(t\)).

Table 2 shows the expected rate of levy and the associated riskiness for a range of alternative sets of subjective probabilities, and demonstrates the familiar

<table>
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<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>100% 1% - 99% 0%</td>
<td>(E(t))</td>
<td>(E(p^*))</td>
<td>(V(t))</td>
<td>(sd(p^*))</td>
</tr>
<tr>
<td>(m) 1 - ((m+n)) (n)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1      0          0</td>
<td>100</td>
<td>-2.70</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0.8    0.2        0</td>
<td>90</td>
<td>-0.95</td>
<td>0.056</td>
<td>4.17</td>
</tr>
<tr>
<td>0.7    0.2        0.1</td>
<td>80</td>
<td>0.80</td>
<td>0.127</td>
<td>6.23</td>
</tr>
<tr>
<td>0.5    0.4        0.1</td>
<td>70</td>
<td>2.55</td>
<td>0.143</td>
<td>6.62</td>
</tr>
<tr>
<td>0.2    0.8        0</td>
<td>60</td>
<td>4.30</td>
<td>0.107</td>
<td>5.72</td>
</tr>
<tr>
<td>0      1          0</td>
<td>50</td>
<td>6.05</td>
<td>0.083</td>
<td>4.95</td>
</tr>
<tr>
<td>0.5    0          0.5</td>
<td>50</td>
<td>6.05</td>
<td>0.25</td>
<td>8.75</td>
</tr>
<tr>
<td>0.3    0.4        0.3</td>
<td>50</td>
<td>6.05</td>
<td>0.183</td>
<td>7.49</td>
</tr>
<tr>
<td>0.2    0.5        0.3</td>
<td>45</td>
<td>6.93</td>
<td>0.164</td>
<td>7.09</td>
</tr>
<tr>
<td>0      0.8        0.2</td>
<td>40</td>
<td>7.80</td>
<td>0.107</td>
<td>5.72</td>
</tr>
<tr>
<td>0.1    0.5        0.4</td>
<td>35</td>
<td>8.68</td>
<td>0.144</td>
<td>6.65</td>
</tr>
<tr>
<td>0.1    0.3        0.6</td>
<td>25</td>
<td>10.43</td>
<td>0.138</td>
<td>6.49</td>
</tr>
<tr>
<td>0      0.5        0.5</td>
<td>25</td>
<td>10.43</td>
<td>0.104</td>
<td>5.65</td>
</tr>
<tr>
<td>0      0.3        0.7</td>
<td>15</td>
<td>12.18</td>
<td>0.078</td>
<td>4.89</td>
</tr>
<tr>
<td>0      0.1        0.9</td>
<td>5</td>
<td>13.93</td>
<td>0.031</td>
<td>3.07</td>
</tr>
</tbody>
</table>

(Based on average UK 1984/5 values of T and p. See Note 1)
result that similar expected levies may be associated with different degrees of riskiness, as measured by the standard deviation of $p^*$. If the marginal cost of over-quota production in the region of the quota level is between 7 and 10 pence per litre (rough estimate based on Nix, 1984), then, for example, over-quota production may be attractive to risk-neutral producers providing that they expect the rate of levy to be no more than 35% and that this, in turn, is compatible with a 10% subjective probability given to the occurrence of a 100% levy, and a 60% probability attached to a non-zero levy.

This section has demonstrated that a rational decision to exceed quota is theoretically consistent with plausible subjective probability distributions for the levy, and that producers require information on gross surplus and deficit in order to form these probabilities rationally.

5. Output decisions in the short run

In this section, short-run decisions are investigated on the simplifying assumption that the only variable input is concentrate. This may not always be realistic even in the very short run. However, in general, feeding is more flexible at the margin than are other aspects of the dairy enterprise, and indeed frequent fine-tuning of variables like cow numbers or stocking rates would have deleterious medium-term consequences for the herd and overall farm planning.

It is also assumed that achievement of the producer’s yearly target requires achievement of monthly or fortnightly targets, which are seasonally adjusted proportions of annual targets. The decisions examined in this section relate to short-term targets, but will generally imply revisions to annual targets as well. Finally, since $p^*$ for over-quota production is not known until the end of the year whereas concentrate price is known when short-run feeding decisions are taken, we assume here that all the profit uncertainty comes from output price (via the super levy).

Adapting Baron (1970), the first order condition for the expected utility-maximizing producer with a single variable input, concentrate, requires that expected marginal value product is equal to marginal factor cost, with some adjustment for risk, i.e.

$$E(p^*) \frac{dy}{dc} = p_c + R^* \frac{dy}{dc}$$

(2)

where $c$ is concentrate and $p_c$ is the price of concentrate. The risk adjustment depends on the producer’s attitude to risk and is proportional to the marginal physical product of concentrate. Furthermore, using a Taylor series expansion of the utility function around $E(\pi)$ it can be shown that $R$ here depends positively on the variance of expected marginal price, $V(p^*)$ (Anderson, Dillon and Hardaker, 1977: 163).2
Producers will be revising their plans in the short run as their subjective probabilities change during the year. For example, if the dairy is in interim deficit and if, as the year progresses, it appears increasingly likely that no levy will be paid, \( E(p^*) \) will converge on \( p \) from below and \( V(p^*) \) will go to zero. For a risk-averse producer, these two changes reinforce each other. His expected marginal value product curve shifts out, whereas the right-hand side of (2) falls. An incentive is thus created for him to expand output in the short run, thereby lowering the marginal product of concentrate until condition (2) is met. In these circumstances, the risk-neutral producer would also revise his planned production upwards (because of rising \( E(p^*) \)) whereas the direction of the risk-prefering producer's adjustment depends on the net effect of rising \( E(p^*) \) and falling \( V(p^*) \).

These revisions will also occur in a downward direction when \( E(p^*) \) falls during the year due to the increasing probability of a large levy. However, these aggregate upward and downward revisions will not be symmetrical, since for downward revisions only those planning to over-produce will adjust; those who had planned to produce within quota will have no reason to consider short-term downward adjustments. In addition, unanticipated changes in the price of concentrate will have short-run effects which may either reinforce the short-run dynamics produced by farmers' revision of probabilities, or dampen them (if the concentrate price changes as a result of changes in demand by dairy farmers).

6. Conclusions and hypotheses

The analysis has demonstrated that it may be rational for an individual milk producer to plan to produce in excess of his quota, even when the riskiness of this decision lowers his utility. Since the decision depends on his subjective probabilities concerning the size of levy, within-year revisions of this decision may occur as his probabilities evolve during the year. The producer must have information on gross excess and deficit production relative to interim quota targets to be in a position to adapt these probabilities rationally.

The analysis has been carried out at the level of the individual producer. Attempts to aggregate and extrapolate these results to the level of the dairy or the industry raise new and important issues, which are not analysed systematically in this paper. However, the microanalysis clearly implies the possibility of oscillating dynamics for total milk production, and suggests that if production cycles occur they may either be contained within the year or be evident from year to year. Moreover, cyclical fluctuations in aggregate supply are likely to be asymmetric above and below the quota level for the dairy.

Broadly speaking, cyclical fluctuations are more likely the less information producers receive about trends in over- and under-production during the year, the less frequently this information is made available, and the longer the time-lag.
before they receive it. The other key factor here is the size and speed of producers' aggregate response to the information they receive; this will depend on how well they understand the way the levy is calculated, their responsiveness to price and profit incentives, the distribution of attitudes to risk among producers, and the biological and technical constraints on milk production which limit their scope for response. The more risk-averse producers are and the more inflexible are the constraints they face, the more damped any cycles will be. These are empirical questions and, as yet, there is insufficient evidence. Nevertheless, the theoretical analysis supports the following hypotheses about the possible effects of producers' response to Formula B levy uncertainty:

1. The post-quota seasonal pattern of milk production will differ from the pre-quota pattern and be less stable, with less predictable output flows in the latter part of the milk year.

2. Year-to-year instability of milk supply is likely to increase. After a year in which over-producers escape with small or zero levy payments, more producers will be likely to plan to be over-quota the following year either because of a change in their initial subjective probabilities concerning the size of the levy, or because their attitude to risk is modified by the chagrin of seeing other more risk-taking producers making penalty-free profits. Conversely, after a year in which levies are paid, producers may be more cautious, even if their subjective probabilities remain unchanged. (Petit's, 1981, adaptive behaviour model of risky decisions formalises this type of reaction.) If present, these tendencies will increase the possibility of cyclical aggregate behaviour.

3. Both upstream industries (in particular feed and fertiliser manufacturers) and downstream processing industries will face greater uncertainty both within the year and from year to year than before quotas were introduced. Changes in input demand from dairy farmers may provoke input price changes which will help to mitigate milk production cycles but this cannot be relied upon. Dairy cattle prices are likely to fluctuate more, and instability in this market will also affect other livestock markets and supplies.

4. Fluctuating output due to levy uncertainty has implications for resource efficiency. Section 5 suggests that some producers, in the closing months of the year, may be producing levels of output for which they were not efficiently adjusted in the medium term. For example, if they increase output rapidly by increasing concentrate feeding, they are more likely to be moving up one of the short-run higher-cost cost functions in Figure 1 than along the least-cost envelope function which incorporates efficient medium term changes to the farming system. This also holds for short-term downward adjustments. Moreover, in the upstream and downstream industries, it will be more difficult to plan production; fluctuating throughput will create problems for optimal capacity usage and will increase inefficiency in these sectors.

5. The efficiency of the quota regime itself, as a strategy for controlling the
cost of dairy surpluses, could also be impaired if production cycles develop and are synchronised between countries at Community level. Cyclical pressure on intervention storage capacity for dairy products may increase average storage costs. Attempts to smooth out cyclical storage requirements may hinder orderly trading arrangements for surplus disposal. Either possibility would have unplanned and undesirable budgetary implications.

Although there has been some evidence of greater instability in dairying in most EC countries during 1984/5, it is usually dismissed as a temporary over-reaction to a policy change. The theme of this paper is that the Formula B system itself may encourage instability by injecting a new element of uncertainty into milk producers' decisions whilst at the same time frustrating their motivation for profit. Once producers are fully aware of all the implications of the scheme and attempt to exploit it, instability may become a permanent feature of the dairy sector.

Uncertainty about the size of the Formula B levy occurs because individual quotas are 'pooled' within the dairy, and individual deficits are offset against gross over-production. If it were known in advance that there would be no under-quota production anywhere in the dairy, the levy would be 100% of target price and known with certainty. There are several reasons why this is unlikely to arise even when the sector has fully adjusted to producing under the quota system. Hubbard (1982) (for the UK, Denmark and the Netherlands) and Buckwell et al. (1983) (for Scotland) show that, even in the expansionary 1970s, some herds of all sizes were becoming smaller, probably for a variety of economic and other reasons. The policy uncertainty which must remain as long as the EC milk sector is in surplus may increase this tendency if it encourages producers to diversify away from milk (MacLaren, 1980). Disease and other setbacks may put individual producers below quota in a particular year, and the wider the geographical area covered by a single dairy, the more likely are regional differences in weather conditions to cause unplanned deficits in the same year that other producers are in surplus. (Crabtree, 1984, reports that in the first four months of 1984/5, milk deliveries to the Aberdeen MMB had a standard deviation around quota of 24% of quota). On the other hand, there would be complete certainty about the size of the Formula B levy if a free market in renting unused annual quota were permitted to develop, in which case it could be safely predicted that there would be no deficit within the dairy in a year of overall surplus. In this case, however, there would be strong pressure to opt for Formula A, with its certain levy of only 75% of target price.

As already indicated, Formula B allows an element of de facto quota transferability, to the extent that the dairy's gross deficit is offset against its gross excess. Whilst policy-makers resist more orderly methods of permitting quota transfer between producers, ad hoc transfers (from under- to over-producers) take place without regulation under the existing scheme. The consequences of these transfers for the efficiency of the industry would be neutral or even beneficial if (a) over-producers are the most efficient in the industry and (b)
these transfers (and therefore milk production systems) could be planned so that appropriate medium-term adjustments are made. Regarding (a), the analysis in this paper suggests that one category of over-producers will have low marginal costs and presumably high efficiency whereas another group may over-produce simply because they enjoy risky situations or have optimistic subjective probabilities. More conclusively, it is clear that condition (b) cannot be satisfied within the existing regulations.

NOTES

1. Average UK values for 1984/5: target price \( T = 17.5 \) pence, price received by producers \( p = 14.8 \) pence.
2. When the utility function is approximated by the first two terms of the expansion the condition in (2) can be expressed as

\[
E(p*) \frac{dy}{dc} = p_c + REDQ \cdot \frac{dy}{dc}
\]

where \( REDQ \) (the risk evaluation differential quotient) = \(-\frac{\delta U/V(\pi)}{\delta U/E(\pi)}\) (these changes offsetting each other so as to keep utility constant). The sign of \( REDQ \) varies with attitude to risk in the same way as that of \( R \).

REFERENCES


The impact of quotas on the optimal adjustment of milk production at the farm level

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Summary

An economic model is developed for the optimal adjustment of milk production on an individual farm faced with a delivery quota. The model is based on the general neoclassical theory of production, taking into account the complicated relations between the production of milk and beef. The application of the model is illustrated by some examples with varying assumptions. The results show that in the short- and medium-term the adjustment should take place by a simultaneous reduction in the feed input and in the number of cows in the herd. As expected, the long-run adjustment should take place only by a reduction in the number of cows.

1. Introduction

Faced with a delivery quota less than his present milk production, the individual farmer has two options. He can reduce the number of cows or he can reduce the feed input to the individual cows.

How the optimal adjustment to the given quota is carried out is not immediately obvious. The shape and place of the production function, the price of beef and the costs of feed and other inputs will play a decisive role. It is also of importance that a reduction in the number of cows involves an integer problem which may be of particular importance to small herds. Furthermore, the individual cows in a herd may have different production functions.

The adjustment of milk production by a reduction in the feed input is complicated by the joint production of milk and beef. A reduction of feed input in the lactation period will reduce the weight gain as well as the milk production. However, a reduced weight gain in the lactation period will have to be compen-
sated during the time between the lactation periods if the cow is to continue in the herd as a productive milk producer.

It is the objective of the present paper to develop an economic model for the optimal adjustment of milk production under an introduced quota system. The principles for production of single products under various control programmes, e.g. acreage control, are well known. However, we know of no recent literature treating the adjustment of production to a quotation of one product in a joint production with rather complicated production relations.

It is our purpose to show some generally applicable principles for deriving the optimal adjustment in the short and the long run and to illustrate the principles by some practical examples. An understanding of the optimal principles of adjustment at the micro level seems also to be a prerequisite for the understanding of the reaction of the whole sector.

The analysis is carried out in two steps. First the criterion for optimal adjustment is derived under the simplified assumption that all the cows in the herd have identical production functions. On the basis of this assumption, a model is built and then is used on empirical data. In the second step, the original assumption is relaxed and the criterion for optimal adjustment is derived under the condition that the cows in the herd have different production functions. This criterion is then also applied to empirical data.

2. General theory

In this section, we shall assume identical production functions of the cows and that there is no distinction between different types of feed.

To adjust his milk production, the farmer has two decision variables, i.e. the number of cows in the herd \( X_1 \) and the feed input per cow \( X_2 \). The total milk production \( M \) from the herd can be written as

\[
M = X_1 \cdot f(X_2),
\]

where \( f \) is the milk production function for the individual cow.\(^1\)

The feed input \( X_2 \) not only affects the milk production but also the weight gain, as milk and beef are joint products. Therefore the beef production has to be considered explicitly by the production function for beef

\[
T = X_1 \cdot g(X_2).
\]

Here \( g \) is the function for weight gain of the individual cow and \( T \) is the total weight gain in the herd.\(^2\)

With milk price \( P_m \) and beef price \( P_k \), the total revenue\(^3\) from the herd is

\[
TR = P_m \cdot X_1 \cdot f(X_2) + P_k \cdot X_1 \cdot g(X_2)
\]

(1)
The total costs of production can be divided into three groups:

1. Costs which vary with both $X_1$ and $X_2$, i.e. feed costs. These costs can be written $X_1 \cdot X_2 \cdot P_{X_2}$, where $P_{X_2}$ is the price of feed.

2. Costs which vary only with $X_1$, i.e. costs for breeding, veterinary services, labour and interest on the herd capital. The sum of these costs is reduced by the value of calves born (see note 3) and the resulting (net) costs per cow are termed $P_{X_1}$. Thus, the total for the herd is $X_1 \cdot P_{X_1}$.

3. Costs independent of either $X_1$ or $X_2$, i.e. the fixed costs (FC) such as interest, depreciation and maintenance of buildings and machinery. Dealing with fixed costs implies that we assume a time horizon where buildings and machinery are assumed to be fixed factors of production.

The total costs of production are given by:

$$TC = X_1 \cdot (P_{X_2} \cdot X_2 + P_{X_1}) + FC$$

and the total profit by $TR - TC$, i.e.

$$P = P_m \cdot X_1 \cdot f(X_2) + P_k \cdot X_1 \cdot g(X_2) - X_1 \cdot (P_{X_2} \cdot X_2 + P_{X_1}) - FC$$

Assuming profit maximization, $P$ should be maximized with respect to $X_1$ and $X_2$ under the constraint that total milk production must not exceed the given quota ($M$) for the herd.

$$X_1 \cdot f(X_2) \leq M.$$  \hspace{1cm} (3a)

We assume that the optimal production without the quota constraint is greater than the quota. Therefore the adjustment in $X_1$ and/or $X_2$ will not be greater than (3a) being fulfilled with an equal-sign. Thus it is possible without limitations to rewrite (3a) as

$$X_1 \cdot f(X_2) = M.$$  \hspace{1cm} (4)

The number of cows cannot exceed the existing capacity of the stalls, so we assumed a fixed capacity.

$$X_1 \leq K,$$  \hspace{1cm} (5)

where $K$ is the present number of cows.

As the profit is linear in $X_1$, we can maximize $P$ without considering the constraint given by (5). If the optimal solution violates (5), such a solution has to be rejected and commonsense tells us that, under such circumstances, we should keep the present number of cows and reduce the feed input until (4) holds.
To maximize (3) with respect to $X_1$ and $X_2$ under the constraint given by (4), we form the Lagrangian function ($L$).

$$L = P_m \cdot X_1 \cdot f(X_2) + P_k \cdot X_1 \cdot g(X_2) - X_1 \cdot (P_{X_2} \cdot X_2 + P_{X_1}) - FC - \lambda \cdot (X_1 \cdot f(X_2) - \bar{M}).$$ \hfill (6)

The optimal solution is found where the partial derivatives of $L$ with respect to $X_1$, $X_2$ and $\lambda$ are equal to zero. These conditions are given by

$$\frac{\partial L}{\partial X_1} = P_m \cdot f(X_2) + P_k \cdot g(X_2) - (P_{X_2} \cdot X_2 + P_{X_1}) - \lambda \cdot f(X_2) = 0 \hfill (7a)$$

$$\frac{\partial L}{\partial X_2} = P_m \cdot X_1 \cdot \frac{df}{dX_2} + P_k \cdot X_1 \cdot \frac{dg}{dX_2} - X_1 \cdot P_{X_2} - \lambda \cdot X_1 \cdot \frac{df}{dX_2} = 0 \hfill (7b)$$

$$\frac{\partial L}{\partial \lambda} = X_1 \cdot f(X_2) - \bar{M} = 0. \hfill (7c)$$

The equations (7a) and (7b) can be changed to (8a) and (8b) as follows:

$$P_k \cdot g(X_2) - (P_{X_2} \cdot X_2 + P_{X_1}) = (\lambda - P_m) \cdot f(X_2), \hfill (8a)$$

$$P_k \cdot X_1 \cdot \frac{dg}{dX_2} - X_1 \cdot P_{X_2} = (\lambda - P_m) \cdot \frac{df}{dX_2} \cdot X_1. \hfill (8b)$$

Dividing (8a) by (8b), a necessary condition for an optimal solution, can be stated as

$$\frac{(P_{X_2} \cdot X_2 + P_{X_1}) - P_k \cdot g(X_2)}{f(X_2)} = \frac{P_{X_2} - P_k \cdot \frac{dg}{dX_2}}{\frac{df}{dX_2}}. \hfill (9)$$

To interpret this condition we look at the total costs in (2). If these costs are reduced by the value of the weight gain, i.e. $X_1 \cdot P_k \cdot g(X_2)$, and if we ignore the fixed costs, the remaining costs are the non-fixed net costs of milk production.$^4$ Division of the net costs of milk production by the total milk production yields a measure of the average production costs ($APC$) per kg of milk:

$$APC = \frac{P_{X_2} \cdot X_2 + P_{X_1} - P_k \cdot g(X_2)}{f(X_2)}. \hfill (9)$$

This expression is equal to the left-hand side of condition (9). The numerator in $APC$ is the non-fixed net costs of milk production per cow. It is easily seen that the marginal costs of milk production$^5$ are given by:
Quota impact on optimal milk production adjustment at farm level

\[ MC = \frac{P_{X_2} - P_k \cdot \frac{dg}{dX_2}}{df \frac{dX_2}{df}} \]  

This expression is equal to the right-hand side in (9).

We are now able to interpret the condition given by (9). The optimal production under a quota constraint is found where the average production costs are equal to the marginal costs. This also means that the average production costs should be minimized.

![Diagram of COSTS AND OPTIMAL FEED INPUT](image)

Figure 1. Costs and optimal feed input

The situation is illustrated in Figure 1. In the upper part of the figure the optimal milk production per cow is seen to be \( m_2 \) kg. The corresponding feed input is indicated in the lower part of the figure, where the milk production function \( f \) is presented.

According to the general theory of production, the optimal level of production without quota constraint is found where the marginal costs of production are equal to the price of milk. This situation is shown in Figure 2, where \( P_m \) is the price of milk and \( m_1 \) is the optimal production per cow.

When a quota system is introduced, the milk production per cow should be reduced from \( m_1 \) to \( m_2 \). If this reduction is not sufficient to fulfill the condition (4), the milk production should be reduced further by a reduction in the number of cows. If, on the other hand, the reduction from \( m_1 \) to \( m_2 \) is more than is
needed to fulfill (4) the reduction in the feed input should not be greater than that needed just to fulfill (4).

Under the given assumptions, the optimal adjustment of milk production can be carried out in one of three ways: (1) to reduce the milk production per cow by a reduction in the feed input; (2) to reduce the number of cows; (3) a combination of 1 and 2. Which of these alternatives will be the optimal one depends on the cost curves and the price of milk, as indicated in Figure 2. If actual average costs of production (APC) are low compared to the price of milk, the main part of the total adjustment should be made by a reduction in the feed input. If APC are high compared to the price of milk, the optimal adjustment should primarily take place by a reduction in the number of cows.

The conclusions relate to a time horizon where the capacity (buildings and machinery) is assumed to be fixed. In the long run, the capacity costs will also be variable costs and hence should be considered in the planning.

The long-run production costs are given by

\[ LRPC = APC + \frac{CC}{f(X_2)} , \]

where CC are the capacity costs per cow.

The long-run production-cost curve is presented in Figure 3 together with the original APC curve.

Under perfect competition, the long-run production will adjust to minimum average total costs. Prior to the introduction of a quota, the production per cow will therefore be \( m_3 \). This means that the adjustment in the long run should exclusively be made by reducing the number of cows, while in the short run the reduction, to a larger or smaller extent, should take place by reducing the feed input.
3. Implementation of the model

Implementation of the general results to a real-life situation involves a number of problems caused by the complex biological system in which milk production takes place. The space does not allow a detailed discussion of the model, but a few indications should be given.

First of all, a time period has to be specified. As the normal production cycle for a cow is one year, this period is chosen for the calculation of revenue and costs. Empirically estimated production functions for milk and beef normally relate daily input of feed to daily output of milk and weight gain. For this reason, it is necessary to specify input and output in units per day. Thus, in the following, \( X_2 \) refers to the feed input per day.

The size of the parameters in empirically estimated production functions naturally depends on the time period chosen. The Danish tradition is to cover the first 24 or 36 weeks of the lactation period, but other periods may be chosen. If we generalize, and indicate the relevant time period by \( DA \) days, the total milk production in that period is:

\[
M = X_1 \cdot f(X_2) \cdot DA,
\]

where \( f \) refers to the daily milk production. Equally, the total weight gain in the period is

\[
\text{Weight gain} = X_1 \cdot g(X_2) \cdot DA,
\]

where \( g \) refers to the daily weight gain.

It is important to note that the formulas shown above cover only \( DA \) days of the year. To cover the whole year we have to include the value of production and the costs of feed input for the rest of the year (including feed for weight gain and pregnancy). To solve this problem we have chosen to estimate these
items and to include them in the quantity $P_{X_1}$ in (2). Also in this expression is included the value of the calves born and the value of manure.

It is assumed that the total gain per year is a fixed amount $B$ kg. Therefore, if the feed input $(X_2)$ in the first $DA$ days, and thus the weight gain in that period, is altered, the change has to be offset for the rest of the year so that the total gain will be $B$ kg.

Finally, the feed is divided into two types of different prices, namely (1) basic feed and (2) marginal feed. In practice, the basic feed is roughage and the marginal feed is concentrates. In the model, changes in feed input $(X_2)$ refer to the marginal feed only. The amount of basic feed is assumed, in principle, to be unchanged.

With the specifications above, the model can be restated as follows:

$$APC = \frac{P_f \cdot (X_2 - G) + G \cdot P_g + \frac{P_{X_1}}{DA} - g(X_2) \cdot FU_t \cdot P_h}{f(X_2)},$$

$$MC = \frac{\frac{df}{dX_2} \cdot FU_t \cdot P_h}{df}$$

where:

- $P_f$ = Price per SFU (Scandinavian feed unit) of marginal feed
- $G$ = Amount of basic feed per cow per day
- $P_g$ = Price per SFU of basic feed
- $FU_t$ = SFU per kg gain in the dry period
- $P_h$ = Price per SFU of feed in the dry period.

The other symbols have the same meaning as stated earlier.

The optimal feed input $(X_2)$ in the first $DA$ days of the lactation period can now be found by solving the equation:

$$APC = MC.$$

If the solution violates the constraint (4) the number of cows $(X_1)$ should be adjusted until (4) is just fulfilled. After this the optimal values of $X_1$ and $X_2$ have been determined.

4. Example

The following example is based on production functions estimated by Østergaard (1979) and Østergaard and Neimann-Sørensen (1983). The production functions are estimated for the first 36 weeks of the lactation period, i.e. 252 days $(DA)$. 
Milk: \[ f(X_2) = -39.7 + 7.41 \cdot X_2 + 0.226 \cdot X_2^2. \]

Weight gain: \[ g(X_2) = 2.9075 - 0.4204 \cdot X_2 + 0.01672 \cdot X_2^2. \]

Other parameters used in the example are based on different Danish sources and refer to typical values in 1984. The parameter values are:

- \( P_f = 2.25 \) D.kr. per SFU (price of marginal feed)
- \( G = 9 \) SFU per day (roughage)
- \( P_g = 1.40 \) D.kr. per SFU (price of roughage)
- \( FU_f = 4 \) SFU per kg gain (feed for gain in dry period)
- \( P_h = 1.40 \) D.kr. per SFU (price of feed for gain in dry period)
- \( P_m = 2.30 \) D.kr. per kg (price of milk)
- \( P_x = 3,052 \) D.kr. per year (net costs per cow - independent of the milk yield)

The quota in the example relates to the quota allotted to Danish farmers in 1984/85, namely 93.3% of their production in 1983. The results are presented in Table 1.

Table 1. Adjustment of feed input. Quota 93.3% of original quantity. Milk and feed per cow per day, week 1-36 of lactation

<table>
<thead>
<tr>
<th>Without quota</th>
<th>With quota</th>
<th>Adjustment (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feed, SFU</td>
<td>14.69</td>
<td>13.85</td>
</tr>
<tr>
<td>Milk, kg</td>
<td>20.38</td>
<td>19.58</td>
</tr>
</tbody>
</table>

To produce with the lowest average production costs (APC) the feed input has to be reduced by 5.7% which corresponds to a reduction in the milk production of 3.9%. However, the reduction should be a total of 6.7% and consequently the number of cows should also be reduced.

The number of cows to be sold is calculated as follows:

Milk per cow before quota: \( 20.38 \cdot 252 + 1000 \) 11
Milk per cow after reduced feeding: \( 19.58 \cdot 252 + 1000 \)
Quota: \( 0.933 \cdot 6136 \)
Reduction in the number of cows: \( \frac{5934-5725}{5934} \) = \( 3.5\% \)

To conclude, the optimal adjustment would be to reduce the feeding in the first 36 weeks of the lactation by 5.7% and to sell 3.5% of the cows.

The effect of changing parameter values is shown in Table 2.

A change in the labour cost, which was fixed at 90 D.kr in Table 1, has a significant influence on the results. Because changes in the number of cows are assumed to change the labour demand by 40 hours per cow, a high opportunity cost of labour means that a high proportion of the adjustment should be made by a reduction in the number of cows. With a low opportunity cost of labour...
Table 2. *Optimal adjustment under different conditions*

<table>
<thead>
<tr>
<th>Conditions</th>
<th>Reduction in Number of Cows (%)</th>
<th>Reduction in Feed (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Basic, as Table 1</td>
<td>3.5</td>
<td>5.7</td>
</tr>
<tr>
<td>2. Higher price on marginal feed (2.50 D.kr.)</td>
<td>4.2</td>
<td>4.3</td>
</tr>
<tr>
<td>3. Higher price on roughage (1.80 D.kr.)</td>
<td>5.5</td>
<td>2.8</td>
</tr>
<tr>
<td>4. Lower wages (60 D.kr.)</td>
<td>0</td>
<td>9.9</td>
</tr>
<tr>
<td>5. Higher wages (120 D.kr.)</td>
<td>5.2</td>
<td>3.0</td>
</tr>
<tr>
<td>6. Higher production (+ 10%)</td>
<td>2.9</td>
<td>6.9</td>
</tr>
</tbody>
</table>

(60 D.kr. per hour) the total adjustment should take place by a reduction in feed input.

5. **The model revised**

Until now we have assumed that all the cows in the herd have identical production functions. We shall now relax this assumption and allow for productive differences among the cows in the herd. If cows are to be sold to reduce milk production it is, of course, profitable to sell the cows with the lowest productivity. Let us therefore assume that the herd is divided into two groups, namely a group of 'productive' cows and a group of 'less productive' cows.

The 'productive' cows are all assumed to have identical production functions, \( F \) for milk and \( G \) for weight gain. The 'less productive' cows have also identical functions but these are different from those of the 'productive' cows, \( f \) for milk and \( g \) for weight gain. The feed input may accordingly be different, and we let \( X_2 \) be feed input to the 'less productive' cows and \( X_3 \) feed input to the 'productive' cows. Furthermore, let \( X_1 \) be the number of 'less productive' cows and \( A \) the number of 'productive' cows.

The total milk production is:

\[
M = X_1 \cdot f(X_2) + A \cdot F(X_3)
\]

and the total weight gain is:

\[
T = X_1 \cdot g(X_2) + A \cdot G(X_3).
\]

Assuming \( P_{X_2} = P_{X_3} \), the total profit can be written as:

\[
P = P_m \cdot [X_1 \cdot f(X_2) + A \cdot F(X_3)] + P_k \cdot [X_1 \cdot g(X_2) + A \cdot G(X_3)]
- X_1 \cdot (P_{X_2} \cdot X_2 + P_{X_1}) - A \cdot (P_{X_2} \cdot X_3 + P_A) - iFC.
\]
The profit has to be maximized with respect to \( X_1, X_2 \) and \( X_3 \) under the constraints that:

\[
X_1 \cdot f(X_2) + A \cdot F(X_3) \leq \bar{M}, \quad X_1 + A \leq K.
\]

Before maximizing, we shall have to make assumptions concerning the relations between the functions \( f \) and \( F \) and between \( g \) and \( G \) respectively. One assumption could be that \( f \) and \( g \) in the relevant area are simple parallel displacements of \( F \) and \( G \) respectively, i.e.:

\[
f(X) = F(X) - k_1 \quad (k_1 > 0),
\]

\[
g(X) = G(X) - k_2 \quad (k_2 > 0).
\]

It is easily seen that an optimal feeding means \( X_2 \) equal to \( X_3 \) because \( P_{X_3} \) is assumed to be equal to \( P_{X_2} \). Therefore \( X_3 \) can be substituted by \( X_2 \) and the optimization can be made in the two variables \( X_1 \) and \( X_2 \).

Another assumption could be that \( f \) and \( F \) are related by a factor \( k \), i.e.

\[
f(X) = k \cdot F(X) \quad (0 < k < 1).
\]

Under this assumption, an optimal feeding means that \( X_2 \) is different from \( X_3 \), say \( X_3 = P(X_2) \). It can be shown that:

\[
P(X_2) = r + q \cdot X_2,
\]

where \( r \) and \( q \) are constants, the value of which depends on the constant \( k \), the prices of milk and beef and the parameters in the production functions.

In the following example we shall assume that:

\[
f(X) = k \cdot F(X), \text{ and}
\]

\[
g(X) = G(X).
\]

Thus we assume a multiplicative difference between the milk production functions, while the production functions for weight gain are identical.

To solve the optimization problem it is convenient to assume the group of 'less productive' cows \( (X_1) \) to be very small compared to the group of 'productive' cows \( A \). If that is the case, it can be proved that the optimization criterion is:

\[
\frac{P_{X_2} \cdot X_2 + P_{X_1} - P_k \cdot g(X_2)}{f(X_2)} = P_{X_2} - P_k \cdot \frac{dG}{dp(X_2)} = P_{X_2} - P_k \cdot \frac{dF}{dp(X_2)}
\]
This condition is identical, in principle, to the condition shown in Section 2. (Formula 9). The difference is that here we have the left-hand side as the average production costs for the 'less productive' cows, while the right-hand side is the marginal costs for the 'productive' cows. The criterion for optimal production can thus be stated as:

$$APC ('less\ productive\ cows') = MC ('productive\ cows').$$

6. Example of use of the revised model

As shown in Section 3, the general optimization model has to be transformed into an operational model for empirical calculations. Although more complicated, the procedure is in principle identical to the one shown in Section 3. Therefore we shall not repeat the procedure here.

The milk production function for the 'productive' cows is:

$$F(X) = -39.7 + 7.41 \cdot X - 0.226 \cdot X^2$$

and for the 'less productive' cows:

$$f(X) = 0.85 \cdot F(X).$$

This means that the 'less productive' cows have a milk production of 85% of the 'productive' cows. Other data are the same as in Section 4. The results are shown in Table 3.

<table>
<thead>
<tr>
<th></th>
<th>Without quota</th>
<th>With quota</th>
<th>Adjustment (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>'Productive' cows</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feed, SFU</td>
<td>14.69</td>
<td>14.32</td>
<td>2.5</td>
</tr>
<tr>
<td>Milk, kg</td>
<td>20.38</td>
<td>20.07</td>
<td>1.5</td>
</tr>
<tr>
<td><strong>'Less productive' cows</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feed, SFU</td>
<td>14.31</td>
<td>13.87</td>
<td>3.1</td>
</tr>
<tr>
<td>Milk, kg</td>
<td>17.05</td>
<td>16.66</td>
<td>2.3</td>
</tr>
</tbody>
</table>

The feed input should now be reduced by 2.5% corresponding to a reduction in the milk production of 1.5%. The rest of the adjustment should be made by selling 'less productive' cows. By a calculation similar to the one shown in
Section 4, we find that the herd should be reduced by 6.4% beginning with the lowest yielding cows.

Comparing the results with those of Section 4, where all cows were assumed to be 'productive', the reduction in feed input should be smaller when some cows yield below average. The results correspond to what might be expected, i.e. that the lower the milk yield, the more important are the savings in costs related to the cows (veterinary service, labour etc).

7. Conclusion

The delivery quota system, introduced in the EC Common Agricultural Policy, implies that the individual farmers have to curtail their milk production. This adjustment of production should be made so that the allotted quota is produced with the minimum average costs.

The farmer can either reduce his capacity (number of cows) or he can reduce capacity utilization (feed input). In the short run, which in milk production may be of considerable length, the capacity costs (measured as opportunity costs) are often low compared to the feed costs. Consequently, the adjustment should primarily take place by a reduction in feed input. In the long run, the capacity costs are higher and the general result is that the adjustment should take place by reducing the number of cows. The process of adjustment is therefore highly dependent on the relation between fixed and variable costs. The opportunity cost of labour, in particular, has a significant influence on the optimal path of adjustment. Great differences in yield between the cows in the herd may imply that even short-run adjustment should be made by selling the less productive cows.

The EC quota system does not allow negotiable quotas. This condition may reduce the economic efficiency in the sector. We shall not elaborate on this subject, but it should be observed that the framework of the present analysis could also be used for an analysis of eventual quota prices.

NOTES

1. \( f \) is assumed to be continuous with \( f' > 0 \) and \( f'' < 0 \) within the relevant area.
2. \( g \) is assumed to be continuous with \( g' > 0 \) and \( g'' > 0 \) within the relevant area.
3. The total revenue should in fact also include the value of calves born. However, it is appropriate in this connection to include this value as a reduction in the costs of production. (See later, under costs of production).
4. As milk is the main product in the joint production of milk, beef (weight gain) and calves, the costs of beef and calves are assumed to be equal to the product value. Therefore, the net cost of milk production is calculated by deducting the value of weight gain from the total costs. (Observe that the value of calves has been included earlier as a reduction in the costs \( P_{X_1} \).)
5. The marginal cost of milk production is calculated by:

\[
\frac{\partial TC_m}{\partial X_1} = \frac{\partial TC_m}{\partial X_2} \cdot \frac{dX_2}{dX_1}
\]

where \( TC_m \) is the non-fixed net cost of milk production per cow.

6. If the price of milk in Figure 2 was \( a \), the adjustment should take place solely by reducing the number of cows.

7. For a detailed discussion of the practical implementation we refer to an extended Danish version of the paper, Rasmussen and Nielsen (1984).

8. If the cow is to continue to function as an efficient milk producer, a certain amount of weight gain is necessary – particularly in the early years.

9. In practice, this depends on the feeding principles. If roughage is fed \textit{ad libitum}, some substitution may take place when the amount of concentrates is changed. This can result in a higher marginal price of feed than the price of concentrates. Therefore, the marginal price of feed is not necessarily equal, in this connection, to the price of concentrates.

10. In certain cases, the solution may violate constraint (5). If that is the case, the optimal solution is to keep the number of cows \( X_1 \) and to adjust \( X_2 \) until (4) is fulfilled.

11. An estimated fixed milk yield in the period after the first 36 weeks of the lactation.

12. \( X_1 \) can always be defined as a group of only one cow (the least productive) and then we can use the optimization criterion (shown later) stepwise.

REFERENCES


The effect of changes in prices and quotas:
An example of the use of an agricultural sector model
based on the Johansen Approach

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Institute of Economics, University of Aarhus, Denmark

Summary

The consequences for agricultural income and production of price and quota changes are calculated using an agricultural sector model for the EC as a whole. The model uses the Johansen solution method which makes it possible to avoid unrealistic separability assumptions between inputs and outputs. The model is used to calculate the lump sum payment and the decrease in the milk price which corresponds to a reduction in the sales of milk by 5% using quota regulation. The model is also used to provide a tentative forecast for the evolution of agricultural production and income during the period 1982-1987. The results seem to suggest that agricultural production and income will increase significantly over the forecasting period even with a 'prudent' price policy.

1. Introduction

The purpose of this paper is to illustrate how an agricultural sector model which employs the Johansen solution method may be used for policy analysis and

* A previous version of this paper has been presented at a seminar organized by the European Institute of Public Administration.

The results presented in this paper have been calculated using a computer model based on the Johansen solution method. I am happy to acknowledge the help I have received from David Vincent who first introduced me to the practical aspects of using this methodology. Comments by Jacques Vonthron, Louis Mahé, Ulrich Koester and Jean Marc Boussard have also been helpful.

The data for the intrasectoral consumption in the EC have been estimated with the assistance of the Institut für Agrarpolitik, Universität Bonn. I am grateful for the help I have received, and in particular for the assistance of Wolfgang Wolff.

The work for this paper was made while I visited 'Centre d'Economie Mathematique et d'Econometrie, Université Libre de Bruxelles'. The computer runs presented in this article were made at the computer centre of 'Université Libre de Bruxelles'. The support in this and other respects is gratefully acknowledged.
medium-term forecasting involving quota regulation in the context of the EC agricultural policy.

The paper draws on work which is in progress. It is the intention to specify the model at the level of each EC member state and to attempt to estimate the parameters of the model by a combination of econometric methods and expert opinion. In this paper, the model is specified at the level of the EC as a whole and the parameters used are meant to be mainly illustrative. It has not been possible to include a full description of either the model or the intended estimation methodology in this paper. For this, the interested reader is referred to Munk (1985a) and Munk (1985b) which may be obtained from the author.

The remaining part of this paper is organized as follows. In Section 2, the structure of the model is explained in general terms. Section 3 contains two examples of the use of the model for policy analysis and one example of its use for forecasting. The effects of a change in the quota for milk are compared with the effects of a price decrease reducing the production of milk by the same amount as the quota. The last example provides a tentative forecast for the period 1982–1987 taking into account the introduction of the quota regulation for milk in 1981. In a concluding section, the main features of the model are emphasized and the direction of future research indicated.

2. The model

2.1. The structure of the model

The model is based on the assumption that the behaviour of the agricultural sector can be seen as the result of profit maximization subject to the constraint of a constant returns to scale technology.

The model consists of two parts (see Figure 1): a production process representing gross agricultural production on the one hand and three production processes representing intrasectoral feed production on the other hand. The sum of the input-output vectors of these production processes corresponds to the agricultural accounts as published by EUROSTAT indicating the net sales of agricultural outputs and the net purchases of intermediate inputs to the agricultural sector from the rest of the economy. The output and input items included in the gross production activity are indicated in column 3 of Table 1. The items included in each of the three intrasectoral feed production processes are indicated in columns 4, 5 and 6 of Table 1.

For certain products, there is no transaction with the rest of the economy. These products are sugarbeet-leaf, sugarbeet-pulp, green fodder and fodderbeet on the output-side and primary feedstuff on the input-side. The prices of these products are called internal prices. The prices of other outputs and intermediate inputs are called market prices.

The market prices of outputs and intermediate inputs are exogenous to the
Some outputs and intermediate inputs may also be specified exogenously to represent quota regulation. Also the quantities of the primary factors of production are specified exogenously.

The internal prices are determined endogenously by the model. For those products which are under quota-regulation, shadow prices are calculated. The model also calculates the gross output and intermediate input quantities for the items not under quota-regulation and the quantities of the inputs and outputs of the intrasectoral feed-production processes. From these, the net sales of agricultural outputs and the net purchases of intermediate inputs to the agricultural sector can be calculated. From the exogenously specified market prices and the calculated quantities of net sales and net purchases, the gross value added of the agricultural sector is calculated.

In the EC, most agricultural prices are institutional and most non-agricultural inputs to the agricultural sector are not dependent on what happens in the agricultural sector. Therefore, it does not constitute a problem to treat these prices as exogenous.

The quantities of the primary factors of production and the prices of agricultural products such as potatoes and concentrated feedstuff which are not institutionally determined are to a greater or lesser extent determined in an interplay between the agricultural sector and the rest of the economy (the other production sectors, the household sector and the foreign sector). The evaluation
Table 1. The aggregation structure of the gross production process and the input output structure of the intrasectoral feed production process

<table>
<thead>
<tr>
<th>Level 3</th>
<th>Gross Production</th>
<th>Level 2</th>
<th>Level 1</th>
<th>Intrasectoral Feed Production</th>
<th>Agricultural Accounts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crop production</td>
<td>Cereals</td>
<td>Wheat</td>
<td>-Wheat</td>
<td>= Wheat</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rye</td>
<td>-Rye</td>
<td>= Rye</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Barley</td>
<td>-Barley</td>
<td>= Barley</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Oats</td>
<td>-Oats</td>
<td>= Oats</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gran maize</td>
<td>-Gran maize</td>
<td>= Gran maize</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Other cereal</td>
<td>-Other cereal</td>
<td>= Other cereal</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rice</td>
<td>-Rice</td>
<td>= Rice</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Potatoes</td>
<td>Potatoes</td>
<td>-Potatoes</td>
<td>= Potatoes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Industrial crop</td>
<td>Dried pulse</td>
<td>-Dried pulse</td>
<td>= Dried pulse</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Oilseed</td>
<td>-Oilseed</td>
<td>= Oilseed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sugar beet</td>
<td>Sugar beet</td>
<td>-Sugar beet</td>
<td>= Sugar beet</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sugar beet leaf</td>
<td>-Sugar beet leaf</td>
<td>= Sugar beet leaf</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sugar beet pulp</td>
<td>-Sugar beet pulp</td>
<td>= Sugar beet pulp</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Vegetables</td>
<td>Vegetables</td>
<td>-Vegetables</td>
<td>= Vegetables</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fruit</td>
<td>Fruit</td>
<td>-Fruit</td>
<td>= Fruit</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Citrus fruit</td>
<td>-Citrus fruit</td>
<td>= Citrus fruit</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wine</td>
<td>-Wine</td>
<td>= Wine</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Olives</td>
<td>-Olives</td>
<td>= Olives</td>
<td></td>
</tr>
<tr>
<td>Other crop prod.</td>
<td>Other crop prod.</td>
<td>Other crop prod.</td>
<td>Other crop prod.</td>
<td>Other crop prod.</td>
<td></td>
</tr>
<tr>
<td>Other primary feed</td>
<td>Green fodder</td>
<td>Green fodder</td>
<td>Green fodder</td>
<td>Green fodder</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fodder beet</td>
<td>Fodder beet</td>
<td>Fodder beet</td>
<td></td>
</tr>
<tr>
<td>Cattle and prod.</td>
<td>Other ani. and prod.</td>
<td>Notes:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----------------</td>
<td>---------------------</td>
<td>--------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cattle</td>
<td>Pigs and pork</td>
<td>1. Items preceded by a dash are intermediate inputs or primary factors of production.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Milk</td>
<td>Sheep and goat meat</td>
<td>2. In the column for intrasectoral feed production the numbers ¹, ² and ³ indicate that the item belongs to the concentrated feedstuff, primary feedstuff and milk feedstuff activities, respectively.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beef</td>
<td>Pork meat</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Veal</td>
<td>Sheep and goat meat</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Milk sold</td>
<td>Other animal prod.</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Milk int. cons.</td>
<td>Other animal prod.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beef</td>
<td>Poultry meat</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Veal</td>
<td>Eggs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Milk int. cons.</td>
<td>Other animal prod.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>= Nitro. fertilizer</td>
<td>Primary feedstuff</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>= Phosph. fertilizer</td>
<td>Conc. feedstuff</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>= Potas. fertilizer</td>
<td>Milk feedstuff</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>= Soil conditioner</td>
<td>Other animal prod.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>= Seed intersectoral</td>
<td>Other animal prod.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>= Plant protection</td>
<td>Other animal prod.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>= Concentration: feedstuff</td>
<td>Other animal prod.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>= Milk</td>
<td>Milk</td>
<td>Labour</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>= Milk</td>
<td>Milk</td>
<td>Labour</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>= Milk</td>
<td>Milk</td>
<td>Labour</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The effect of changes in prices and quotas.
Knud Jorgen Munk

of whether the values of these variables (in the model specified exogenously) are consistent with the values of the 'truly' exogenous variables must be made outside the model. The alternative of having endogenized these variables would have significantly increased the complexity of the model and the difficulty of operating the model. It would be highly desirable to expand the model with the non-agricultural feed-processing sector, but this still needs to be done.

The structure of the model is illustrated in Figure 1. The model is specified in terms of percentage changes. This makes it possible to avoid the unrealistic assumption of separability between inputs and outputs which is often made. At the highest level of aggregation, the model can in fact be specified to provide a loglinear approximation to any production structure. The structure of the gross production process is expressed in terms of an aggregation structure and a number of Allen-substitution-elasticities. An Allen-substitution-elasticity may be defined as the percent change in the quantity ratio between two items due to a 1% increase in the corresponding price ratio.

The output and the intermediate input commodities are aggregated from the lowest level to two higher levels (see Table 1). At the highest level (level 3) we distinguish between 3 composite outputs and 4 composite inputs. For each of the 21 different pairs of commodities at the highest level an Allen-elasticity of substitution is specified (see Table 2a)).

At the intermediate level (level 2) we distinguish between 23 composite items. These items are aggregated into the 7 composite items at the highest level using CES-functions, thus imposing separability between the items within one group and the items within any other group. To specify this part of the model, 7 elasticities of substitution need therefore to be specified (see Table 2b), one for each of the 7 groups.

At the lowest level of aggregation (level 1) we distinguish between 47 items, which are aggregated into the 23 composite items at the intermediate level of aggregation by means of CES-functions. To specify this part of the model, a maximum of 23 elasticities of substitution are required. Fewer than 23 are needed because certain items at the intermediate level consist of only one item at the lowest level (see Table 2c).

The relationship between the primary factors of production and the outputs and intermediate inputs are expressed by a matrix of primary factor elasticities indicating the percentage change in an item at the highest level of aggregation due to a 1% change in the quantity of a primary input (see Table 2d).

The separability assumptions implied by the three level aggregation structure (where the primary factors of production are put at the same level as the 7 items at the highest level of aggregation) and the assumption of CES aggregation functions are rather strong, but far less restrictive than the assumption of separability between inputs and outputs which is often made. It does not pose any theoretical difficulty to avoid this assumption. However, to specify the model without the aggregation structure would require the estimation of 1081 (= 47 × 46 / 2) independent substitution-elasticities. The assumptions concerning the aggregation-
Table 2. Parameter values

(a) substitution-elasticities between items at level 3

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Crop production</td>
<td>-.6</td>
<td>.0</td>
<td>-1.0</td>
<td>.1</td>
<td>.1</td>
<td>-.5</td>
<td></td>
</tr>
<tr>
<td>2. Cattle and prod</td>
<td>-.5</td>
<td>.3</td>
<td>-1.0</td>
<td>-.5</td>
<td>-.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Oth. ani. and prod</td>
<td>.0</td>
<td>-.3</td>
<td>-1.5</td>
<td>-.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Crop cost</td>
<td>.0</td>
<td>.0</td>
<td>.0</td>
<td>.0</td>
<td>.0</td>
<td>.0</td>
<td></td>
</tr>
<tr>
<td>5. Primary feed</td>
<td>1.0</td>
<td>.0</td>
<td>.0</td>
<td>.0</td>
<td>.0</td>
<td>.0</td>
<td></td>
</tr>
<tr>
<td>6. Oth. ani. cost</td>
<td>.0</td>
<td>.0</td>
<td>.0</td>
<td>.0</td>
<td>.0</td>
<td>.0</td>
<td></td>
</tr>
<tr>
<td>7. Oth. cost</td>
<td>.0</td>
<td>.0</td>
<td>.0</td>
<td>.0</td>
<td>.0</td>
<td>.0</td>
<td></td>
</tr>
</tbody>
</table>

(b) substitution-elasticities between items within groups at level 2

1. Crop production | -1.0 |
2. Cattle and prod | .5   |
3. Oth. ani. and prod | .5   |
4. Crop cost | .5   |
5. Primary feed | 1.0  |
6. Oth. ani. cost | .5   |
7. Oth. cost | .5   |

(c) substitution-elasticities between items within groups at level 1

<table>
<thead>
<tr>
<th>Output Groups</th>
<th>Input Groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Cereals</td>
<td>-1.1</td>
</tr>
<tr>
<td>2. Industrial crop</td>
<td>-1.1</td>
</tr>
<tr>
<td>3. Sugar beet</td>
<td>-.01</td>
</tr>
<tr>
<td>4. Fruit</td>
<td>-1.1</td>
</tr>
<tr>
<td>5. Oth. prim. feed</td>
<td>-1.1</td>
</tr>
<tr>
<td>6. Cattle and prod</td>
<td>-1.1</td>
</tr>
<tr>
<td>7. Milk</td>
<td>-1.1</td>
</tr>
<tr>
<td>8. Milk</td>
<td>-1.1</td>
</tr>
<tr>
<td>9. Poultry and eggs</td>
<td>-1.1</td>
</tr>
</tbody>
</table>

(d) Primary factor elasticities

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital</td>
<td>.32</td>
<td>.32</td>
<td>.32</td>
<td>.32</td>
<td>.32</td>
<td>.32</td>
<td>.32</td>
</tr>
<tr>
<td>Labour</td>
<td>.68</td>
<td>.68</td>
<td>.68</td>
<td>.68</td>
<td>.68</td>
<td>.68</td>
<td>.68</td>
</tr>
</tbody>
</table>

(e) Elasticities of substitution in intrasectoral feed production

Concentrated feedstuff | 1.
Primary feedstuff     | 1.
structure reduce the number of parameters needed to specify the model to manageable proportions which in general seem to provide a sufficient justification for the simplifications made.

2.2. Specification of the model

To specify the model base year data for the variables indicated in Table 1 and substitution-elasticities, primary-factor-elasticities and rates of change indicating technical progress have to be estimated.

Table 3. **Primary factor dependent price elasticities at level 3**

<table>
<thead>
<tr>
<th>Supply/demand of</th>
<th>Cro. 1</th>
<th>Cat. 2</th>
<th>Oth 3</th>
<th>Cr.c. 4</th>
<th>Pri. 5</th>
<th>O.ac. 6</th>
<th>Oth.c 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crop production</td>
<td>.61</td>
<td>-.39</td>
<td>.0</td>
<td>-.18</td>
<td>.01</td>
<td>.05</td>
<td>-.10</td>
</tr>
<tr>
<td>Cattle and prod</td>
<td>-.53</td>
<td>1.10</td>
<td>-.20</td>
<td>-.05</td>
<td>-.08</td>
<td>-.24</td>
<td>-.10</td>
</tr>
<tr>
<td>Other ani. and prod</td>
<td>0</td>
<td>-.32</td>
<td>1.16</td>
<td>.0</td>
<td>-.03</td>
<td>-.71</td>
<td>-.10</td>
</tr>
<tr>
<td>Crop cost</td>
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<td>-.19</td>
<td>.0</td>
<td>-.71</td>
<td>.0</td>
<td>.02</td>
<td></td>
</tr>
<tr>
<td>Primary feed</td>
<td>-.09</td>
<td>.65</td>
<td>.12</td>
<td>.0</td>
<td>-1.2</td>
<td>.47</td>
<td>.02</td>
</tr>
<tr>
<td>Other ani. cost</td>
<td>-.09</td>
<td>.65</td>
<td>.40</td>
<td>.0</td>
<td>.09</td>
<td>-1.06</td>
<td>.02</td>
</tr>
<tr>
<td>Other cost</td>
<td>.44</td>
<td>.32</td>
<td>.20</td>
<td>.02</td>
<td>.01</td>
<td>.05</td>
<td>-1.04</td>
</tr>
</tbody>
</table>

The substitution-elasticities are specified in Table 2, and in Table 3 the price-elasticities at the highest level of aggregation (which are derived from the base year data and the substitution-elasticities indicated in Table 2a)) are presented. It should be remembered that these elasticities are contingent on the amounts of the primary factors being kept constant.

The parameter estimates are specified according to estimates which have been reported in the literature. The own price elasticity for milk is consistent with the interval for the likely value for this parameter suggested by the milk study made for the EC Commission (1981) by Hanff, Jones, Boussard, Foulhouze and Vanden Noort. For other estimates, inspiration has been drawn from the estimates used by Buckwell et al. (1982). The specification of value shares for primary inputs and the specification of the rates of technical change for these inputs have been based on the study by Behrens and de Haen (1980).

This way of specifying the parameters is obviously not entirely satisfactory. A methodology has been laid down for how to estimate the parameters of the model (see Munk, 1985b). The intention is, as a first step, to estimate a translog transformation function or translog profit-function on time series data for each member state using the method described by Christensen, Jorgensen and Lau (1973). In the second step, the substitution-elasticities can then be derived from the estimated parameters of the translog function at a given data point. Experience shows however, that it is very difficult to obtain useful results by
purely econometric methods. It is difficult to take the dynamics into account in a proper way to avoid biased results. In general some elasticity estimates come out with the wrong sign (see e.g. McKay et al., 1983). It is therefore a useful feature of the model that all parameters can be given a clear intuitive interpretation, and that the specification can be made partly on the basis of expert opinion.

2.3. The solution of the model

From a mathematical point of view, the model may be expressed as a system of $N$ equations in $M$ variables where $M$ is greater than $N$. One set of equations expresses gross output supply and gross input demand contingent on the amount of primary factors. Other sets of equations express the intrasectoral demand for certain agricultural outputs, zero profit conditions for the intrasectoral production activities and the equilibrium conditions for those agricultural outputs which are entirely used within the agricultural sector and those inputs which are entirely supplied by the agricultural sector itself.

All equations are specified in loglinear form. The whole model may therefore be formulated as

$$A v = 0$$

where $A$ is a $N \times M$-dimensional matrix of elasticities and $v$ an $M$-dimensional vector of percentage changes.

The first step in using the fully specified model is to close the model by dividing the vector of variables $v$ into a vector of $N$ endogenous variables $v_1$ and an $(M-N)$ vector of exogenous variables $v_2$, and by partitioning the $A$ matrix accordingly in an $N \times N$-dimensional $A_1$ matrix and an $N \times (M-N)$-dimensional $A_2$ matrix. A solution for specified values of the exogenous variables may then be found simply by matrix inversion as

$$v_1 = -A_1^{-1}A_2v_2$$

This method of solving a model is called the Johansen method after the Norwegian economist Leif Johansen who first used this method to solve big general-equilibrium models. The method involves a linearization error which, however, may be eliminated by the use of Euler's method (see Dixon et al., 1982).

The traditional neoclassical closure of the model involves choosing the quantities of outputs and intermediate inputs as endogenous variables and the market prices and the quantities of primary factors of production as exogenous. The model may, however, quite easily be used to evaluate the effects of the introduction of a quota scheme by choosing the quantity of the products affected by the quota scheme as exogenous and the corresponding (shadow) prices as endogenous. The use of the model to calculate the effects of quota changes...
does, however, in general require base year data also for the shadow prices of the restricted products. It should also be emphasized that this use of the model assumes either that all farms are identical or that the quotas are freely transferable.

3. The use of the model for policy analysis and forecasting

To illustrate how the model may be used for both policy analysis and medium-term forecasting involving quota-regulation, three runs have been made:

The first run shows the effect of a 5% decrease in the quota for milk and of an unchanged quota for sugarbeet.

The second run shows the effect of decreases in the prices producing the same effect on production as in the first run.

The final run provides a tentative forecast of the changes in production and income during the period 1982-87.

3.1. Policy analysis: Quota on milk and sugarbeet (see Table 4)

The model shows that a 5% reduction in the quota for milk together with no change in the quota for sugarbeet decreases the shadow price of milk by 7.2% the shadow price of sugarbeet by 1.6%. The model shows the important effects for products other than the ones directly effected. The model shows, for instance, how the quota-regulation will increase (+1.6%) the amount of cereals produced. The amount of cereals sold will, compared with the amount produced, be further increased (+2.5%) due to the reduction in the intrasectoral use of cereal (-1.4%). The model calculates the effect on income of the quota-change to be null. This is because there is no quota in the initial situation and because the change in the quota in the calculations is considered to be 'small'.

3.2. Policy analysis: Decrease in prices inducing the same change in production as the quota change (see Table 5)

This run illustrates the theoretically well-known result that the effect on production and income of a quota-scheme is the same as for certain changes in the prices of the commodities under quota-regulation combined with a lump-sum payment. In this case, the quota-change considered in run 1 produces the same effect as decreases in the prices of milk and sugarbeet by 7.2 and 1.6% respectively combined with a lump-sum payment corresponding to 2.6% of value added. Lump-sum payments, naturally, do not (according to economic theory) affect production decisions as such, i.e. they have no substitution effect.

Considering the household sector which is not covered by the model, a lump-sum payment may, however, have a positive income effect on the supply of agricultural labour; when a farmer becomes poorer he may not any longer feel that
Table 4. Quota on milk and sugarbeet

<table>
<thead>
<tr>
<th></th>
<th>Change in Quantity produced for intrasectoral use</th>
<th>Change in Quantity sold</th>
<th>Production value $= (100 + (1)) \times \frac{100 + (3)}{(100 + (3)) - 100}$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Price market</td>
<td>shadow internal</td>
<td></td>
</tr>
<tr>
<td>Total output</td>
<td>-0.1</td>
<td>-0.4</td>
<td>-0.5</td>
</tr>
<tr>
<td>Crop production</td>
<td>-0.2</td>
<td>1.3</td>
<td>1.2</td>
</tr>
<tr>
<td>of which</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-cereals</td>
<td>0.0</td>
<td>1.6</td>
<td>-1.4</td>
</tr>
<tr>
<td>-sugarbeet</td>
<td>0.0</td>
<td>-1.6</td>
<td>0</td>
</tr>
<tr>
<td>Dairy/cattle</td>
<td>0.0</td>
<td>-4.0</td>
<td>-4.0</td>
</tr>
<tr>
<td>of which</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-milk</td>
<td>0.0</td>
<td>-7.2</td>
<td>2.9</td>
</tr>
<tr>
<td>-cattle</td>
<td>0.0</td>
<td>-3.6</td>
<td>-3.6</td>
</tr>
<tr>
<td>Other animal</td>
<td>0.0</td>
<td>1.3</td>
<td>1.3</td>
</tr>
<tr>
<td>Total int. input</td>
<td>-0.2</td>
<td>-0.9</td>
<td>-1.1</td>
</tr>
<tr>
<td>Crop cost</td>
<td>0.0</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Animal cost</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>of which</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-roughage</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-concentrate</td>
<td>-1.9</td>
<td>0.3</td>
<td>-2.2</td>
</tr>
<tr>
<td>and other</td>
<td>0.0</td>
<td>-1.4</td>
<td>-1.4</td>
</tr>
<tr>
<td>Other cost</td>
<td>0.0</td>
<td>-1.4</td>
<td>-1.4</td>
</tr>
<tr>
<td>Primary factors</td>
<td>-2.6</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Labour (man units)</td>
<td>-3.9</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Capital (physical units)</td>
<td>.0</td>
<td>.0</td>
<td>.0</td>
</tr>
</tbody>
</table>

Note:
Assumptions about exogenous changes:
- the amount of milk will be reduced by 5% and the amount of sugarbeet will be kept unchanged by quota regulation
- all prices will remain unchanged.

He can afford to work at the low (shadow) wage in the agricultural sector and may start to work in the urban sector, even if the wage differential has not changed. The use of labour in the agricultural sector has both in this and in the previous run been assumed to be fixed, and in both runs suffers the same fall in shadow price. In comparing the effect of price and quota-changes, the negative effect on the agricultural labour supply of using prices rather than quotas to curb production should be taken into consideration, which, in terms of the present model, can be done by specifying an exogenous decrease in the amount of labour in the case where the decrease in production is achieved by price-
Table 5. Decrease in prices inducing the same change in production as the quota change

<table>
<thead>
<tr>
<th>Change in</th>
<th>Price market shadow or internal</th>
<th>Quantity produced for intra-sectoral use</th>
<th>sold</th>
<th>Production value = ((100 + (1)) \times (100 + (3)) - 100)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total output</td>
<td>-1.4</td>
<td>-0.4</td>
<td>-1.8</td>
<td></td>
</tr>
<tr>
<td>Crop production</td>
<td>-0.3</td>
<td>1.3</td>
<td>1.1</td>
<td></td>
</tr>
<tr>
<td>of which</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-cereals</td>
<td>0.0</td>
<td>1.6</td>
<td>-1.4</td>
<td>2.5</td>
</tr>
<tr>
<td>-sugarbeet</td>
<td>-1.6</td>
<td>0.0</td>
<td>-1.6</td>
<td></td>
</tr>
<tr>
<td>Dairy/cattle</td>
<td>-3.9</td>
<td>-4.0</td>
<td>-7.7</td>
<td></td>
</tr>
<tr>
<td>of which</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-milk</td>
<td>-7.2</td>
<td>-4.2</td>
<td>2.9</td>
<td>-5.0</td>
</tr>
<tr>
<td>-cattle</td>
<td>0.0</td>
<td>-3.6</td>
<td>-3.6</td>
<td></td>
</tr>
<tr>
<td>Other animal</td>
<td>0.0</td>
<td>1.3</td>
<td>1.3</td>
<td></td>
</tr>
<tr>
<td>Total int. input</td>
<td>-0.2</td>
<td>-0.9</td>
<td>-1.1</td>
<td></td>
</tr>
<tr>
<td>Crop cost</td>
<td>0.0</td>
<td>0.5</td>
<td>.5</td>
<td></td>
</tr>
<tr>
<td>Animal cost of which</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-roughage</td>
<td>-1.9</td>
<td>-0.3</td>
<td>-2.2</td>
<td></td>
</tr>
<tr>
<td>-concentrate and other</td>
<td>0.0</td>
<td>-1.4</td>
<td>-1.4</td>
<td></td>
</tr>
<tr>
<td>Other cost</td>
<td>0.0</td>
<td>-1.4</td>
<td>-1.4</td>
<td></td>
</tr>
<tr>
<td>Primary factors</td>
<td>-2.6</td>
<td>0.0</td>
<td>-2.6</td>
<td></td>
</tr>
<tr>
<td>Labour (man units)</td>
<td>-3.9</td>
<td>0.0</td>
<td>-3.9</td>
<td></td>
</tr>
<tr>
<td>Capital (physical units)</td>
<td>.0</td>
<td>.0</td>
<td>.0</td>
<td></td>
</tr>
</tbody>
</table>

Note:
Assumptions about exogenous changes:
- the price of milk will be reduced by 7.2% and the price of sugarbeet by 1.6%
- sugarbeet kept unchanged by quota regulation
- all other prices will remain unchanged

fall rather than by quota-regulation. In order to illustrate the equivalence with respect to the effect on production of price and quota changes, this has not been done here.

3.3. Forecast for the period 1982-1987 (see Table 6)

This run illustrates the use of the model for medium-term forecasting. Compared to the policy runs, this requires the specification of the expected changes in pro-
The effect of changes in prices and quotas

Table 6. Forecast for the period 1982-1987

<table>
<thead>
<tr>
<th>Change in</th>
<th>Price shadow or internal</th>
<th>Quantity for intra-sectoral use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total output</td>
<td>-0.4 7.2 6.6</td>
<td></td>
</tr>
<tr>
<td>Crop production of which</td>
<td>-4.7 9.1 4.0</td>
<td></td>
</tr>
<tr>
<td>- cereals</td>
<td>-10.0 7.5 12.6 4.7 -3.2</td>
<td></td>
</tr>
<tr>
<td>- sugarbeet</td>
<td>-5.0 -12.5 .0 -5.0</td>
<td></td>
</tr>
<tr>
<td>Dairy/cattle of which</td>
<td>4.7 -1.2 3.4</td>
<td></td>
</tr>
<tr>
<td>- milk</td>
<td>4.5 -24.8 -2.3 22.2 -5.0 2.1</td>
<td></td>
</tr>
<tr>
<td>- cattle</td>
<td>5.0 0.4 5.4</td>
<td></td>
</tr>
<tr>
<td>Other animal</td>
<td>1.0 16.5 17.7</td>
<td></td>
</tr>
<tr>
<td>Total int. input</td>
<td>-4.7 6.5 1.4</td>
<td></td>
</tr>
<tr>
<td>Crop cost</td>
<td>-1.5 5.1 3.5</td>
<td></td>
</tr>
<tr>
<td>Animal cost of which</td>
<td>-7.6 5.0 -3.0</td>
<td></td>
</tr>
<tr>
<td>- roughage</td>
<td>-7.9 10.2 1.5</td>
<td></td>
</tr>
<tr>
<td>- concentrate and other</td>
<td>0.0 0.2</td>
<td></td>
</tr>
<tr>
<td>Other cost</td>
<td>.2</td>
<td></td>
</tr>
<tr>
<td>Primary factors</td>
<td>3.7 7.8 11.8</td>
<td></td>
</tr>
<tr>
<td>Productivity</td>
<td>13.7</td>
<td></td>
</tr>
<tr>
<td>Labour (man units)</td>
<td>27.0 -10.0 15.0</td>
<td></td>
</tr>
<tr>
<td>Capital (physical units)</td>
<td>0.0 5.0 5.0</td>
<td></td>
</tr>
</tbody>
</table>

Note:
Assumptions about exogenous changes:
- the amount of milk will be reduced by 5% and the amount of sugarbeet kept unchanged by quota regulation
- prices of cereals will be reduced by 10% in nominal terms (corresponding to 28% in real terms at 20% inflation) as well as the price of cereals for feed and seed
- the price of industrial crops will be reduced by 5% only
- the prices of fruits, beef, veal, poultry and milk will increase by 5%
- all other prices of agricultural products will remain unchanged
- all non-agricultural input prices will change in line with inflation
- the productivity of labour and capital will increase by 10% and, on top of this, there will be a further 5% productivity increase in the production of cereal and milk

The changes in prices and quotas and the expected changes in the amounts of the primary factors of production. These assumptions must naturally be made in the light of the assumptions made about the changes in the other exogenous variables of the model.
It has been assumed that over the period 1982-1987, the amount of capital in the agricultural sector will increase by 5%, whereas the amount of labour (in man units) will decrease by 10%. The productivity is assumed to increase by 15% for capital and by 10% for labour. It is further assumed that cereals will experience a 5% increase in productivity over and above the increase in productivity attributed to the primary factors of production.

With respect to changes in prices and quotas, the following assumptions are made:

The amount of milk will be reduced by 5% by quota-regulation and with the amount of sugar beet kept unchanged. Prices of cereals will be reduced by 10% (in real terms). The prices of concentrated feedstuff and seed will be reduced by the same amount, whereas the price of dried pulses, potatoes, sugar beet, oilseed, industrial crops will be reduced by 5%. The prices of fruit, citrus fruit, beef, veal, poultry meat and milk are assumed to increase by 5%. All other prices are assumed to be constant.

The forecast based on these assumptions has a number of interesting features: In spite of the decrease in the relative price by 10% the production of cereals will increase by 7.5%. The shadow price of milk, i.e. the cost of producing an extra unit of milk, will fall by nearly 25%. Taken together with the increase in the market price of milk by 5% this implies that the market price will be 40% (30/75*100%) over the shadow price. This will give a strong incentive to sell milk by non-official channels.

The model forecasts that the production of beef meat will stay relatively constant whereas the production of other types of pork and poultry meat will increase by nearly 16.5%. The forecast for the change in income is also interesting. Even with a rather ‘prudent’ price policy, income will increase by nearly 12% in real terms.

4. Direction of future research and other concluding remarks

First it should be emphasized that the results presented here should be seen as an illustration of the attraction of this modelling approach in general and of the agricultural sector model in particular rather than precise forecasts. The model brings together a set of individually relatively well-known relationships which, however, taken together constitute a rather complex whole. Therefore, even when the model has been better validated, its main purpose will be to draw the attention of decision-makers to some possibly overlooked consequences of individually well established relationships.

The model is in the process of being improved in three ways: (1) the model will be specified at the level of individual member states; (2) attempts are being made to estimate translog transformation functions for each member state from which the substitution-elasticities needed to specify the
model may be derived and; (3) the model will be extended with a sector representing the processing of feedstuffs outside the agricultural sector.

Even with these improvements the model will remain essentially an agricultural sector model. The modelling approach makes it, however, relatively easy to extend the model by submodels of the other production sectors, the household sector, the government sector (see e.g. Keller, 1981) and to model intra-EC and extra-EC trade (see e.g. Vincent, 1983). These submodels may then be run individually or together as a proper CGE (Computable General Equilibrium) model at the level of individual member state or the EC as a whole. Such a project requires a major international effort in terms of data collection and modelling which it would take several years to complete, but, as this paper seems to demonstrate, using the Johansen approach, it will be possible to construct and operate useful submodels along the way.

To summarize: a model has been constructed which, in principle, can be estimated by existing econometric methods or which can be specified on the basis of expert knowledge. As a tool for medium-term forecasting and for policy analysis in a policy-making context, the model seems to strike a satisfactory compromise between making unrealistic simplifying assumptions and creating a model so complicated that it can be specified and operated only with major difficulty. It has been demonstrated how, by using the same model, both the consequences of quota and price changes for agricultural production and income may be evaluated on a sound theoretical basis. The methodology used provides a framework for creating a CGE model which allows the present model to be used either in a stand-alone mode or as part of the more comprehensive model.

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Budgetary and financial effects of the EC milk quota system

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Summary

Results are reported from using an existing model of the CAP to analyse the dairy quota scheme introduced by the European Community in April 1984. Modifications to the model for this purpose include the use of quota-equivalent prices to capture the effect of dairy quotas on other enterprises within the agricultural sector. The quota policy is contrasted with a reference policy chosen to represent the continued evolution of pre-1984 policy. Results are presented for the three years 1984, 1985 and 1988. Constraining milk production causes the Community to become more self-sufficient in cereals, but slightly less so in livestock products. By 1988, net FEOGA expenditure in the milk sector is estimated to be around 40% less with the quota policy than under the reference policy, though total net FEOGA expenditure is reduced by only half this amount. As would be expected, taxpayers savings are estimated to exceed greatly the loss suffered by dairy producers.

1. Introduction

This paper reports the results of adapting an existing model of the Common Agricultural Policy (CAP) in order to analyse the dairy quota scheme introduced by the Council of Ministers on 1 April 1984. The model has been described elsewhere by Buckwell et al. (1982) and by Thomson (1985). Briefly, comparative-static submodels of the markets for sixteen CAP commodities in each member state of the European Community (EC) are used to calculate the effects of changes in CAP instruments such as intervention prices on the quantities produced, consumed and traded in the Community. Thus the budgetary and economic outcomes of alternative policy situations can be compared. Cross-elasticities are used to capture inter-relationships such as resource competition.
and intermediate markets between commodities, and third-country effects are included using a rest-of-world component. The model has been used over a period of several years to evaluate the effects of annual price package decisions and for other specific tasks (Thomson and Hubbard, 1982; Harvey and Thomson, 1984).

The introduction of the dairy quota scheme presented a challenge, since, in common with many other modelling approaches, prices rather than quantities were the usual policy instruments in the equations. However, two features pointed the way towards the modifications necessary to incorporate milk quotas. First, the CAP regime for sugar has involved quotas since its inception, and these are included in the model specifications as primary data. Second, model solution has always been sequential (by commodity) rather than simultaneous, partly for reasons of computational simplicity, and partly because some commodity regimes, such as those for sugar, beef and milk products, differ markedly and do not permit identical treatment. For some model uses, such as estimation of a 'free trade' situation, iteration of this sequential solution process is necessary so that the effects of market changes for commodities solved later in this process can be translated back to other markets.

Dairy quotas are therefore handled in the following way. National levels of quota are imposed as absolute upper limits on milk production in each country, over-riding any higher levels produced by the usual supply equations. Should the quota be effective as a constraint, a quota-equivalent price (QEP) is calculated as that price for milk which would have brought about a reduction in supply to the quota level. The QEPs are then used to re-calculate, using cross-elasticities, the production levels of all other commodities. This reflects the transfer of resources such as land and labour from dairy to non-dairy enterprises as well as the knock-on effects of reduced supplies of milk on beef, veal and milk products. The possibility of over-quota milk production and the consequent payment of supplementary levies is ruled out.

Although QEPs have been introduced to represent producers' behaviour in farming as a whole, in reality the CAP milk price is higher than QEP by a rental value corresponding to the administrative limitation of quota. While the reduction in milk supply may come about in several ways, it is to be expected that the average productivity of at least some inputs such as feed and dairy animals themselves will rise due to the law of diminishing marginal productivity. Total levels of their inputs and their overall cost will be liable to fall, however, leaving the producer with the rental values referred to above. The distribution of this value depends eventually on several factors, including the workings of the markets in land and labour as the basic factors of production. These features will vary from country to country and from farm to farm, making it difficult to determine even the medium-term destination of quota values, though in the long-term the well-known tendency for policy support to accrue to land values would be expected to show itself.

Even from this brief description, it is clear that a heavy weight is placed on
the values of the elasticity-coefficients used. Some of these are reported in Table 1, and represent long-run ('full adjustment') elasticities. The milk coefficients are differentiated by country and are taken from an EC study (Commission, 1981), whereas the cross-elasticities representing the effect of changing milk prices (or quantities as represented by the QEPs) on other products are applied in all member states for lack of more detailed data.

Table 1. Supply elasticities with respect to milk price

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Country</th>
<th>Elasticity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk</td>
<td>Germany</td>
<td>0.9</td>
</tr>
<tr>
<td></td>
<td>France</td>
<td>1.8</td>
</tr>
<tr>
<td></td>
<td>Italy</td>
<td>2.5</td>
</tr>
<tr>
<td></td>
<td>Netherlands</td>
<td>1.1</td>
</tr>
<tr>
<td></td>
<td>Belgium</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td>United Kingdom</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>Eire</td>
<td>0.7</td>
</tr>
<tr>
<td></td>
<td>Denmark</td>
<td>0.4</td>
</tr>
<tr>
<td></td>
<td>Greece</td>
<td>1.3</td>
</tr>
<tr>
<td>Beef and veal</td>
<td>EC</td>
<td>0.5</td>
</tr>
<tr>
<td>Cereals</td>
<td>EC</td>
<td>-0.25</td>
</tr>
</tbody>
</table>

Two policies were run for each of the three years 1984, 1985 and 1988. The first of these, the reference policy, represents most closely the continued evolution of pre-1984 policy. The method employs constrained extrapolation of production and consumption trends in each member state and commodity since 1976 (Thomson, 1984). This implies nominal changes in CAP support prices below the rate of cost increases, i.e. real prices falling as in recent years under the 'prudent' price policy. In addition to the price effects, the estimated quantities take into account the underlying shifts in supply and demand reflecting changes in technology, tastes and income levels.

The alternative to the reference policy is the quota policy, as introduced by the Community in April 1984. This differs from the reference quantity in that milk production in each member state is constrained by the imposition of a quota; the EC global quota totals 99.570 million tonnes for 1984 and 98.363 million tonnes for 1985 and thereafter. As part of the quota package, the co-responsibility levy was raised by 1 percentage point during 1984 to offset the extra costs of the higher level of quota; this is also specified in the model. An important additional feature of this policy option is the inter-sectoral effect estimated through the calculation and use of QEPs.
2. Results

Table 2 shows deliveries and consumption of milk under the policy alternatives for the three years. With a continuation of recent policy, milk deliveries are estimated to be in excess of 115 million tonnes by 1988, and the surplus over consumption at 27 million tonnes. Total deliveries of milk in the Community in 1984 are shown as 0.5 million tonnes less than the global quota due to deliveries in Ireland, Italy, Belgium and Greece falling short of the quota. However, quotas in all member states except Greece become binding after 1985. QEPs shown in the lower half of Table 2 indicate that real milk prices in the Community would need to fall by around 5, 8 and 14% in 1984, 1985 and 1988 to achieve supply reductions equivalent to the quota constraints.

Table 2. Production, deliveries and prices

<table>
<thead>
<tr>
<th></th>
<th>Reference policy</th>
<th>Quota policy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quota (m.t)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Deliveries (m.t)</td>
<td>105.2</td>
<td>107.7</td>
</tr>
<tr>
<td>Surplus over consumption (m.t)</td>
<td>18.0</td>
<td>20.6</td>
</tr>
<tr>
<td>Average producer price (Ecu/t)</td>
<td>274.5</td>
<td>274.5</td>
</tr>
<tr>
<td>Average QEP (Ecu/t)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>QEP as % of producer price</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 3 shows the self-supply situation for the main commodity groupings under the alternative policies. Under the reference policy, self-supply indices in milk, cereals and livestock products are projected to be 131%, 136% and 104% respectively by 1988, with an overall self-supply in CAP products of 116%. The quota policy clearly reduces self-supply for milk, though deliveries remain substantially in excess of Community consumption. The constraint in milk production imposed by the quota results in an increase in cereal production and self-supply. The effect on the livestock sector is to reduce slightly the self-supply situation under the reference policy.

The effect on CAP expenditure of these changing levels of self-supply is shown in Tables 4 and 5. Table 4 shows FEOGA expenditure on the milk sector under the alternative policies. Under the reference policy, gross (net) FEOGA expenditure is shown to increase from 5.4 (4.5) billion ECU in 1984 to 6.8 (5.8) billion ECU in 1988. The effect of the quota policy is to reduce gross (net) FEOGA expenditure in the sector to 5.1 (3.4) billion ECU by 1988. Net expenditure is thus estimated to be reduced by around 40% over five years by the quota policy compared to the reference outcome. However, expenditure in real terms still increases even with quotas in place.

The gross FEOGA expenditures for milk are reproduced in Table 5 along with
Table 3. *EC self-supply by main commodity groups*

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Reference Policy</th>
<th>Quota Policy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk</td>
<td>120.6</td>
<td>123.6</td>
</tr>
<tr>
<td>Cereals</td>
<td>129.1</td>
<td>127.9</td>
</tr>
<tr>
<td>Livestock</td>
<td>102.2</td>
<td>102.0</td>
</tr>
<tr>
<td>Total</td>
<td>112.1</td>
<td>112.4</td>
</tr>
</tbody>
</table>

The corresponding figures for the cereal and livestock sectors. As with the dairy sector, expenditure on cereals and livestock is projected to increase in the reference policy situation, largely because of underlying shifts in supply outstripping shifts in demand. The effect of these shifts is to increase total gross (net) expenditure from 19.1 (16.8) billion ECU in 1984 to 23.5 (21.7) billion ECU by 1988. The inter-sectoral effects of the quota policy on FEOGA expenditure are to increase the cost of the cereal sector and to slightly reduce real expenditure on livestock. The overall effect is to limit total net expenditure in 1988 to around 1 billion ECU above its 1984 level of 16.8 billion ECU.

The quota policy can be expected to result in losses for milk producers and processors across the Community and gains for taxpayers. Estimates of these changes are shown in Table 6. In all member states the gain to taxpayers as a result of the much reduced burden of net FEOGA expenditure greatly outweighs producers’ losses, being about six times as large. By the nature of the model, gains to producers of other commodities are not readily calculated, since other prices have not been altered, and the additional supplies are treated as being produced at marginal cost.

3. Discussion

This short paper does not allow full presentation and discussion of the model output which covers both individual countries and commodities. However, the EC-level results do highlight the major effects of the milk quota policy in comparison with the likely outcome under a continuation of the policies of the recent past. The milk surplus is initially (1984) reduced by about a quarter, and held at around 14 million tonnes instead of rising to twice that level by 1988. The Community remains in substantial over-supply of butter and milk powder, however, and an overall index of agricultural self-supply in most CAP products still increases from around 111 to 114. Since these surpluses of cereals, livestock products and sugar, as well as milk, are expensive to remove, total gross FEOGA Guarantee expenditure in real terms continues to escalate, though 'only' by 16% by 1988 instead of 23% under the reference situation. Net expenditure, to be
Table 4. *FEOGA* expenditure in the milk sector

<table>
<thead>
<tr>
<th>Item</th>
<th>Reference policy</th>
<th></th>
<th>Quota policy</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Refunds</td>
<td>2804 3048 3679</td>
<td>2280 2214 2454</td>
<td>(-19) (-27) (-33)</td>
<td></td>
</tr>
<tr>
<td>Intervention</td>
<td>2136 2190 2370</td>
<td>2040 2041 2084</td>
<td>(-4) (-7) (-12)</td>
<td></td>
</tr>
<tr>
<td>Gross FEOGA¹</td>
<td>5443 5793 6750</td>
<td>4712 4639 5058</td>
<td>(-13) (-20) (-25)</td>
<td></td>
</tr>
<tr>
<td>Co-responsibility levy</td>
<td>532 546 584</td>
<td>778 497 497</td>
<td>(-30) (-34) (-42)</td>
<td></td>
</tr>
<tr>
<td>Net FEOGA²</td>
<td>4546 4889 5825</td>
<td>3171 3250 3364</td>
<td>(-30) (-34) (-42)</td>
<td></td>
</tr>
</tbody>
</table>

Notes:
Figures in parentheses under the quota policy show the percentage change on the reference policy for the corresponding year.
1 Gross FEOGA expenditure is that incurred under the Guarantee section of FEOGA prior to the deduction of any revenues.
2 Net FEOGA expenditure is gross FEOGA expenditure minus all import and producer levies on CAP products. It represents the cost of the CAP that has to be met by the Community's taxpayers through VAT contributions.

Table 5. *FEOGA* expenditure

<table>
<thead>
<tr>
<th>Item</th>
<th>Reference policy</th>
<th></th>
<th>Quota policy</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk</td>
<td>5443 5793 6750</td>
<td>4712 4639 5058</td>
<td>(-13) (-20) (-25)</td>
<td></td>
</tr>
<tr>
<td>Cereals</td>
<td>2873 2731 3054</td>
<td>2983 2882 3272</td>
<td>(+4) (+6) (+7)</td>
<td></td>
</tr>
<tr>
<td>Livestock</td>
<td>2196 2156 2308</td>
<td>2072 1972 1971</td>
<td>(-6) (-9) (-15)</td>
<td></td>
</tr>
<tr>
<td>Total gross FEOGA</td>
<td>19062 19995 23469</td>
<td>18103 18454 17687</td>
<td>(-5) (-8) (-10)</td>
<td></td>
</tr>
<tr>
<td>Total net FEOGA</td>
<td>16823 17749 21652</td>
<td>14941 15316 17687</td>
<td>(-11) (-14) (-18)</td>
<td></td>
</tr>
</tbody>
</table>

Note:
Figures in parentheses under the quota policy show the percentage change on the reference policy for the corresponding year.
Table 6. *Economic welfare changes*

Changes in producer surplus and VAT contributions following quota policy compared to reference policy

(a)

<table>
<thead>
<tr>
<th></th>
<th>1984</th>
<th>1985</th>
<th>1988</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk producers</td>
<td>-305</td>
<td>-445</td>
<td>-729</td>
</tr>
<tr>
<td>Taxpayers</td>
<td>+1882</td>
<td>+2433</td>
<td>+3965</td>
</tr>
</tbody>
</table>

(b)

<table>
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<tr>
<th></th>
<th>1988</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk producers</td>
<td>-223</td>
</tr>
<tr>
<td>Taxpayers</td>
<td>+1220</td>
</tr>
</tbody>
</table>

financed by taxpayers, also continues to rise for the milk sector alone. The net effect of the milk quota package is put at around 4 billion ECU by 1988, an 18% reduction in the potential cost of the CAP borne by taxpayers. The estimated effect on the milk sector is an income loss of around 300 million ECU for 1984, 450 million ECU for 1985 and 730 million ECU by 1988. These figures correspond to losses of around 0.3, 0.4 and 0.7 ECU per 100 kg or litre of milk, a small reduction compared to the intervention equivalent of about 27 ECU per 100 kg. To bring about the same reduction in supplies by means of simple price decreases would involve falls of around 5, 8 and 14% in real terms. Thus the quota policy has the obvious political merit of safeguarding the bulk of dairy farmers' incomes by achieving supply control through means other than price.

The simplicities and pitfalls of the approach adopted for this paper are clear. The model used, though not described here, has been constructed to facilitate a simple calculation of economic results based on a relatively straightforward
extrapolation of recent trends. Limited validation is possible by comparison of current-year FEOGA expenditure levels with official budgetary data, but discrepancies between the model's underlying assumptions (such as no changes in stocks and no deferment of payments) make even this exercise of doubtful value. Various complexities of the quota scheme such as the possibility of over-quota deliveries and the shorter-run effects of its sudden introduction in April 1984 have been ignored, as have possible cyclical effects in the beef sector. However, the present method does permit some estimation, albeit crude, of cross-commodity production effects, and of the impact of the quotas and other adjustments on the EC agricultural budget over several future years. This latter point is particularly important since the milk quota scheme was only forced on the Council of Ministers as a result of financial crisis. Its development in the future, and its possible extension to other farming sectors, will depend on how far effective control on the hitherto unstoppable growth in agricultural output and expenditure can be achieved by such means.

REFERENCES


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An evaluation of the effects of the EC quota system on the Italian dairy market*

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University of Naples, Italy
CARLO PERONE-PACIFICO and ALESSANDRO SORRENTINO
Tuscia University, Italy

Summary

The integration of Italy into the EC led to a spectacular increase of milk imports during the seventies, in spite of the increase in domestic production. Using an econometric model of the Italian dairy sector, it is shown that, had quota been established in 1980, imports would have increased even more and, when combined with a price decrease, imports of cheese would also have increased. These effects are comparable to those of a price decrease (without quota) of 9%.

1. Introduction

During the last twenty years, the Italian dairy sector has undergone far-reaching changes associated with the transition from a situation of almost complete self-sufficiency to one of a large structural deficit.

Three important and inter-related phenomena have influenced the progressive integration of Italian trade with that of the rest of Europe:

1. The creation of a single Community market which, whilst aligning the Italian with the European sector both at economic and at trading level, has at the same time imposed unified forms of intervention over a far from homogeneous geographical area. In this context, market policies, strongly influenced by the urgent need to dispose of surpluses arising in certain areas, have operated simultaneously in areas such as Italy where production falls short of consumption, aggravating the problems to be faced there.

2. The particularly dynamic trend in consumption, which appears to have been

* The paper summarizes some of the results of a wider study carried out for the 'Istituto Nazionale di Economia Agraria' (INEA) by Centro di Specializzazione e Ricerche economico-agrarie per il Mezzogiorno, University of Naples, Portici.
stimulated by entrance to the Common Market to a much greater extent than production. In fact, the rapid expansion of demand, which began in the early 1970s seems to be the main cause of the deficit in the Italian dairy sector.

3. The existence of a large dairy processing industry to which the fortunes of Italian milk production are strongly linked. This industry, which processes almost 70% of the milk produced in Italy, deals mainly with the production of Parmigiano Reggiano and Grana Padano cheeses, and because of the particular characteristics of these varieties, it manages to avoid direct competition from cheeses produced in the rest of the Community (Rizzi and Bussi, 1972; Rizzi, 1980).

The main changes which have taken place in the Italian dairy sector are easily detected in the structure of market supply from 1960 to the present time (Table 1). Imports, which were almost non-existent in 1960, and still almost negligible in 1970, developed rapidly in the 1970s. In 1982 they amounted to almost 42 million quintals (in milk equivalent), i.e. about 30% of total supply.

The expansion of imports, made possible by the process of Community integration, is not due to a reduction of domestic productive capacity. Milk production, in fact, not only continued to rise during the 1970s, but grew at an even faster rate than in the preceding decade.

Instead, the causes of the large deficit must be sought on the demand side. Consumption of milk and cheese shows a particularly strong upward trend. Growing at an average annual rate of 2.35% between 1960 and 1970, it exploded in the following decade (Table 2) out of all proportion to domestic production and therefore was increasingly met by supplies from foreign, in particular, Community sources. The dichotomy in the growth rate of consumption is all the more striking if considered with respect to growth rates of income: in fact, income grew much faster in the 1960s than in the 1970s and in the second decade the demand for dairy products appears to have developed independently of it.

It thus seems reasonable to affirm that only as the Italian market became integrated into that of the Community was it possible for consumption to develop unrestrained by productive capacity and to realise the potential which the high increase in income in the preceding decade had made possible.

The way in which the trade deficit has been and will, in the future, be covered is of great importance for the Italian dairy industry. In fact, if imports of milk and of processed products in general both contribute to satisfying the internal deficit, the ratio between them is important and will become even more so in determining the operative environment and the opportunities for development of the domestic processing industry.

Technical innovation in transport facilitated a flow of milk imports during the 1970s which had hitherto been almost non-existent (Table 1). This undoubtedly reduced problems of supply to cheese processors. On the one hand, milk imports were used to satisfy demand for direct consumption, releasing
The effects of the EC quota system on the Italian dairy market

Table 1. The Italian dairy market – supply and end-use, 1960-1980

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<tbody>
<tr>
<td></td>
<td>(thousand quintals)</td>
<td>(% change per annum)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Milk production</td>
<td>73994</td>
<td>77279</td>
<td>82672</td>
<td>87253</td>
<td>98151</td>
<td>1.42</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1960</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1960</td>
</tr>
<tr>
<td>direct consumption</td>
<td>29138</td>
<td>31835</td>
<td>34375</td>
<td>34805</td>
<td>37466</td>
<td>1.26</td>
</tr>
<tr>
<td>processing</td>
<td>44856</td>
<td>45443</td>
<td>48296</td>
<td>52448</td>
<td>60685</td>
<td>1.52</td>
</tr>
<tr>
<td>Milk imports</td>
<td>16</td>
<td>529</td>
<td>1107</td>
<td>6800</td>
<td>13931</td>
<td>40.28</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1960</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>1960</td>
</tr>
<tr>
<td>direct consumption</td>
<td>16</td>
<td>529</td>
<td>1107</td>
<td>5919</td>
<td>8885</td>
<td>37.16</td>
</tr>
<tr>
<td>processing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>881</td>
</tr>
<tr>
<td>Cheese imports</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4039</td>
</tr>
<tr>
<td>milk equivalent</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>17093</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>9.39</td>
</tr>
<tr>
<td>Source:</td>
<td>our calculations on ISTAT data.</td>
<td></td>
<td></td>
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</table>

Table 2. Consumption of dairy products and income in Italy

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<td>1960</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1960</td>
</tr>
<tr>
<td></td>
<td>(thousand quintals of milk equivalent)</td>
<td>(% change per annum)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dairy products cons.</td>
<td>74165</td>
<td>73788</td>
<td>93556</td>
<td>109389</td>
<td>130138</td>
<td>2.85</td>
</tr>
<tr>
<td>Fresh milk</td>
<td>25819</td>
<td>32339</td>
<td>35600</td>
<td>40714</td>
<td>46222</td>
<td>2.39</td>
</tr>
<tr>
<td>processed products</td>
<td>45346</td>
<td>46449</td>
<td>57956</td>
<td>68675</td>
<td>83916</td>
<td>3.12</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(billion lire at 1970 price)</td>
</tr>
<tr>
<td>Income</td>
<td>32086</td>
<td>42403</td>
<td>57546</td>
<td>68158</td>
<td>85753</td>
<td>5.04</td>
</tr>
<tr>
<td>Source:</td>
<td>our calculations on ISTAT data.</td>
<td></td>
<td></td>
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<td></td>
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</tr>
</tbody>
</table>

internal production for processing, and, on the other, they served as raw material for the same processing industry.

The opportunity offered by technological change to acquire raw material on the Community market did not, however, simultaneously enable the Italian processing industry to overcome problems of competition between foreign and domestic products. In fact, the cost of transport from the area of production to that of transformation contributed in no small measure to raising the costs of production of Italian cheese.

Nevertheless, the rate of growth of cheese imports (Table 1) does not appear to be strongly influenced by the deficit in milk supply. On the other hand, there appears to be evidence that, owing to the differentiation between national and foreign products, the Italian processing industry was able to pass on to consumer prices the increase in production costs, thus fending off competition from abroad.
2. Structure of the model

The problems briefly sketched in the previous paragraph justify the choice of the structure of the econometric model: it has been assumed that the cheese market plays a crucial role in determining the allocation of domestic production between fresh and processed products and in determining the composition of total imports with reference to raw-milk and processed product shares. In fact, it is essentially this composition that affects the possibility of survival of the processing industry.

The causal relationships among the endogenous variables of the model are described by the arrow-chart of Figure 1. The model, which is fully reported in the appendix, is orientated around one block of simultaneous equations and a second block of recursive equations. The simultaneous equations analyse equilibrium in the market for cheese. Within this block, demand, supply, net imports, stocks, consumer and wholesale prices of cheese are defined together with producer prices for milk. Equilibrium in the market for cheese is strongly conditioned by import prices for milk and for processed products. Integration of the Italian with the Community market implies that the level of import prices depends on equilibrium positions reached on the European market.

The model is limited to consideration of the Italian market, and it was not possible, with the available data, to endogenise import prices as would have been preferable. It was therefore decided to estimate two simple equations which explain import prices. The latter are considered to depend on the level of the indicative price for milk, monetary compensatory amounts and the level of stocks of products withdrawn from the market by Community intervention agencies.

Producer prices for milk determine the internal level of supply, which is explained in the model by the number of dairy cattle and their productivity. The supply of cheese, on the other hand, determines the quantity of raw material required for the processing industry. The share of this quantity supplied by national production depends on the behaviour of the operators and is determined by the dynamics of the ratio between domestic and import prices. In this way, milk imports for processing and national production for fresh consumption are determined.

The demand for milk imports for fresh consumption depends on the level of domestic consumption and the quantity of milk available on the domestic market for this purpose.

Equilibrium in the market for butter is not analysed in the model, since in Italy this market is quite different from those of other EC member states, both from the point of view of demand, and from that of supply. In fact, demand for butter is strongly conditioned by competition from vegetable oils — in particular, that from olive oil. Supply on the other hand, depends on cheese production, since butter may be considered as a joint product in the manufacture of cheese.

Finally, it must be noted that the model does not specify functions relating
Figure 1. Causal relationships among the endogenous variables of the model
to storage of products subject to Community intervention since these operations have never been carried out in Italy. 1

The model has been run using annual data (ISTAT, a, b, c, d) for the period 1961 to 1981. The block of simultaneous equations was estimated by the two-stage least squares method, whilst for the others, ordinary least squares procedure was used. The equations which explain import price formation were estimated using half-yearly data from 1975 to 1983. The results are shown in the Appendix Tables.2

3. Consequences of quota

Limitation of FEOGA expenditure in support of the dairy sector has necessitated the introduction of measures which could no longer be delayed. The objective of containing costs could be pursued either by reduction of intervention price, or by introducing a super levy on production in excess of a determined quantity. The Council of Ministers, meeting on 31st March 1984, chose the second alternative.

The system of quotas has been applied to all member states of the EC. For Italy, the quota has been fixed at the level of deliveries to dairies in 1983 plus the amount sold directly by producers in 1981 increased by 1% (Servizio informazione agricola CEE, 1984).

In effect, the Council's decision was not limited to the introduction of quotas, but, by leaving the indicative price of milk unchanged, implied a reduction in real terms in the level of support.

To analyse the effects in Italy of the recent decision regarding the dairy sector, simulations were carried out using the model described above. In the absence of more recent data, the effects were evaluated for 1980.3 Three kinds of interventions have been simulated: (A) The stipulation of a guaranteed production quota for 1980 equal to the amount delivered to dairies in 1979 plus the amount sold directly in 1977 by producers increased by 1%, with indicative price set at the current price level. The purpose is to evaluate the effects of limiting the level of production without acting on price. The indicative price level in this simulation is the one actually observed in 1980.

(B) The stipulation of the same quota as in (A), but with the indicative price fixed at the previous year's level: i.e. the policy intervention actually decided by the Council of Ministers in 1984. Since the effects are simulated for the year 1980, prices are set at the 1979 level.

(C) Reduction of the indicative price by 3% and by 9%, without stipulating a guaranteed production quota. The aim of this simulation is to evaluate the possible effects on the Italian dairy industry of a policy measure that would attempt to limit production by acting only on price.

Since production in excess of the quota would be subject to a levy of 75% or
100% of the indicative price, according to the formula chosen by the member country, it may be assumed that, in the short run, supply would not be higher than the quota level, because producers would not deliver milk if they obtained a price close to zero (Cioffi and Sorrentino, 1984). Thus, in simulating the introduction of a quota on the Italian milk supply, it was assumed that the total supply of milk would be less than or equal to the established quota. Thus, if the level of prices was such that total supply would exceed the quota, the supply was set at the quota level.

The results of the simulations are shown in Table 3. In the first column, the values assumed by the variables in the absence of intervention are shown. The remaining columns show the percentage deviations between the values obtained under the different hypotheses of intervention and those resulting in their absence. As may be seen from Table 3, the fixing of a quantitative limit alone would not have changed the price system, but would have had the sole effect of reducing internal supply and increasing milk imports for fresh consumption to cover the lower degree of self-sufficiency.

If a measure similar to that decided in 1984 (hypothesis B) had been enacted in 1980, the effect would, however, have been much stronger. Supply would have been equal to the established quota, while prices would have fallen with a small change in their relative levels. Furthermore, the dependence of Italy on imports would have been much greater. A reduction in the price levels

Table 3. Results of simulations

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Variable*</th>
<th>No Intervention (1)</th>
<th>% Deviation of Simulated Values from those in Col. 1</th>
<th>3%</th>
<th>9%</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>LIR (000 ql.)</td>
<td>98917</td>
<td>-2.22</td>
<td>-0.57</td>
<td>-2.36</td>
</tr>
<tr>
<td></td>
<td>LIC</td>
<td>39492</td>
<td>-5.56</td>
<td>-2.00</td>
<td>-6.08</td>
</tr>
<tr>
<td></td>
<td>LMC</td>
<td>6539</td>
<td>+33.58</td>
<td>+11.40</td>
<td>+34.70</td>
</tr>
<tr>
<td></td>
<td>DLC</td>
<td>46030</td>
<td>-0.21</td>
<td>-0.10</td>
<td>-0.29</td>
</tr>
<tr>
<td></td>
<td>LIT</td>
<td>59427</td>
<td>+0.15</td>
<td>+0.04</td>
<td>+0.11</td>
</tr>
<tr>
<td></td>
<td>LMT</td>
<td>3671</td>
<td>-3.02</td>
<td>-0.71</td>
<td>-2.21</td>
</tr>
<tr>
<td></td>
<td>LT</td>
<td>63098</td>
<td>-0.04</td>
<td>-0.01</td>
<td>-0.03</td>
</tr>
<tr>
<td></td>
<td>SIF</td>
<td>6036</td>
<td>-0.03</td>
<td>-</td>
<td>-0.02</td>
</tr>
<tr>
<td></td>
<td>DF</td>
<td>8314</td>
<td>+0.31</td>
<td>+0.14</td>
<td>+0.43</td>
</tr>
<tr>
<td></td>
<td>S</td>
<td>2037</td>
<td>+1.13</td>
<td>+0.44</td>
<td>+1.37</td>
</tr>
<tr>
<td></td>
<td>K</td>
<td>798</td>
<td>-0.50</td>
<td>-0.38</td>
<td>-1.00</td>
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<tr>
<td></td>
<td>PL (1970=1)</td>
<td>0.97</td>
<td>-4.12</td>
<td>-2.06</td>
<td>-6.19</td>
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<tr>
<td></td>
<td>PLM</td>
<td>0.95</td>
<td>-6.30</td>
<td>-3.70</td>
<td>-11.10</td>
</tr>
<tr>
<td></td>
<td>PIF</td>
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<td>-5.00</td>
<td>-3.00</td>
<td>-7.00</td>
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<tr>
<td></td>
<td>PMF</td>
<td>0.88</td>
<td>-6.80</td>
<td>-3.09</td>
<td>-9.30</td>
</tr>
<tr>
<td></td>
<td>PCF</td>
<td>1.10</td>
<td>-2.73</td>
<td>-1.81</td>
<td>-3.64</td>
</tr>
</tbody>
</table>

* for explanation of abbreviations, see Appendix A2.
(hypothesis C) would have generated changes of the same sign as those of hypothesis B, the size of which would have depended on the percentage change in the supporting price levels.

It would therefore appear that a decision to maintain the indicative price of milk at the level of the previous year, hypothesis B, would have the effect of curbing production to the extent that the supply of milk would end up being almost equal to the quota assigned. Import prices of dairy products would fall in real terms by 6% or 7%, changing the allocation of domestic supply and causing a redistribution of incomes in the sector. Furthermore, there would be a marked increase in milk imports, a slight increase in cheese imports and a sharp reduction in the supply of milk, while the domestic processing industry would maintain the same level of production. The income of the farmers operating in the dairy sector would be particularly affected by this measure: supply would fall by about 2.2% and prices would decline by about 4% in real terms. In this situation producers would experience a sharp reduction in revenue and income, while consumers, traders and, above all, the FEOGA expenditure would benefit.

Italian participation in the reduction of FEOGA costs for dairy support would not have taken the form of a reduction in withdrawals from the market, which have never been effectuated here, but through an even greater contribution to the disposal of surpluses resulting in zones of excess production, the financing of which falls on the Italian balance of trade.

Lack of information relating to other measures for limiting milk production (national incentives for leaving the sector, etc.), important organizational changes which may take place as a result of the new market regulations, and the limits of the model particularly as concerns the formation of equilibria on the Community dairy market prevent extrapolation of conclusions beyond the short-period.

As a concluding remark, it is worthwhile to emphasize the particular position of the Italian dairy sector in that it absorbs a notable share of the EC surplus. As a result of the decisions taken on the 31st of March 1984, Italy will find its deficit position further worsened.

**APPENDIX**


(standard errors are shown in parentheses)

Simultaneous equations

\[ DFP_t = -15.35 - 1.53 \ PCF_t + 18.21 \ PAA_t + 8.60 \ RDP_t \]

\[ (11.25) \quad (1.42) \quad (10.52) \quad (0.78) \]

\[ R^2 = 0.95 \quad DW = 0.96 \]
The effects of the EC quota system on the Italian dairy market

\[ S_t = -967.9 + 673.7 PIF_t - 923.3 PMF_t + 0.25 DF_{t-1} + 47.17 T \]
\[ (724.3) \quad (382.4) \quad (570.0) \quad (0.14) \quad (31.41) \]
\[ R^2 = 0.97 \quad DW = 0.71 \]

\[ PIF_t = -0.71 + 0.79 PL_t + 0.74 PL_{t-1} + 0.03 PLM_t D75 \]
\[ (0.19) \quad (0.29) \quad (0.27) \quad (0.03) \]
\[ + 0.19 PMF_t - 0.5 \times 10^{-4} K_t \]
\[ (0.25) \quad (0.6 \times 10^{-4}) \]
\[ R^2 = 0.88 \quad DW = 1.56 \]

\[ SIF_t = 1911.8 - 690.1 D1963 + 268.7 D75 + 0.65 SIF_{t-1} \]
\[ (825.4) \quad (169.6) \quad (124.2) \quad (0.10) \]
\[ + 1867.9 PIF_t - 1979.9 PL_t \]
\[ (752.4) \quad (1162.2) \]
\[ R^2 = 0.96 \quad DW = 2.33 \]

\[ PCF_t = 0.30 + 0.58 PIF_t + 0.38 SC_t \]
\[ (0.06) \quad (0.09) \quad (0.12) \]
\[ R^2 = 0.88 \quad DW = 1.96 \]

\[ PL_t = 0.18 + 0.44 PIF_t + 0.29 PMF_t + 0.10 PLM_t \]
\[ (0.11) \quad (0.09) \quad (0.15) \quad (0.04) \]
\[ R^2 = 0.87 \quad DW = 2.74 \]

\[ K_t = SIF_t + S_t - DF_t - K_{t-1} \]

Recursive equations

\[ LT_t = 10.45 SIF_t \]
\[ (0.06) \]
\[ R^2 = 0.97 \quad DW = 1.30 \]

\[ LIT_t = 0.998 LT_t - 7381.4 PL_t * D75 + 3817.8 PLM_t * D75 \]
\[ (0.006) \quad (6640.5) \quad (6684.9) \]
\[ R^2 = 0.97 \quad DW = 1.29 \]

\[ DLP_t = 50.01 - 2.30 PC_t + 5.72 PCF_t + 48.88 Q_t \]
\[ (0.35) \quad (12.09) \quad (5.92) \quad (4.38) \]
\[ R^2 = 0.96 \quad DW = 1.45 \]

\[ NVL_t = 1.33 + 0.72 NVL_{t-1} + 0.39 PL_t + 0.40 PL_{t-2} \]
\[ (1.44) \quad (0.12) \quad (0.12) \quad (0.14) \]
\[- 0.13 PCB_{t-2} - 0.18 SA_{t-2} - 0.36 IPM_{t-2} \]
\[ (0.13) \quad (0.05) \quad (0.13) \]
\[ R^2 = 0.92 \quad DW = 1.80 \]
\( \Pi_t = 3.58 + 0.50 \Pi_{t-1} - 0.26 NVL_t + 0.24 T + 0.05 PL_t \\
- 0.08 SA_t - 0.43 IPM_t \\
R^2 = 0.97 \quad DW = 1.84 \)

\( LIR_t = NVL_t \times \Pi_t \)

\( LIC_t = LIR_t - LIT_t \)

\( LMT_t = LT_t - LIT_t \)

\( LMC_t = DDC_t - LIC_t \)

\( PMFX_t = -2.31 + 1.03 PL_t - 0.04 SPL_{t-1} \\
R^2 = 0.99 \quad DW = 2.59 \)

\( PLMX_t = -1.59 + 1.23 PL_t - 0.08 ICM_t - 0.03 SB_{t-1} \\
- 0.04 SPL_{t-1} \\
R^2 = 0.99 \quad DW = 2.72 \)

Notes:

( . ) Logarithmic estimates

(:) Logarithmic estimates - prices not deflated.

A2. List of variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Symbol</th>
<th>Deflator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk supply</td>
<td>LIR</td>
<td>-</td>
</tr>
<tr>
<td>Dairy cows</td>
<td>NVL</td>
<td>-</td>
</tr>
<tr>
<td>Production per cow</td>
<td>( \pi )</td>
<td>-</td>
</tr>
<tr>
<td>Internal cheese supply</td>
<td>SIF</td>
<td>-</td>
</tr>
<tr>
<td>Net cheese imports</td>
<td>S</td>
<td>-</td>
</tr>
<tr>
<td>(Per capita) cheese demand</td>
<td>DF(P)</td>
<td>-</td>
</tr>
<tr>
<td>Cheese stocks</td>
<td>K</td>
<td>-</td>
</tr>
<tr>
<td>Milk processed</td>
<td>LT</td>
<td>-</td>
</tr>
<tr>
<td>Domestic milk processed</td>
<td>LIT</td>
<td>-</td>
</tr>
<tr>
<td>Per capita milk demand</td>
<td>DLP</td>
<td>-</td>
</tr>
<tr>
<td>Milk imports, fresh consumption</td>
<td>LMC</td>
<td>-</td>
</tr>
<tr>
<td>Milk imports processing</td>
<td>LMT</td>
<td>-</td>
</tr>
<tr>
<td>Demand for milk</td>
<td>DLC</td>
<td>-</td>
</tr>
<tr>
<td>Domestic milk, fresh consumption</td>
<td>LIC</td>
<td>-</td>
</tr>
<tr>
<td>Wages in trading sector</td>
<td>SC</td>
<td>IPI</td>
</tr>
<tr>
<td>Beef price</td>
<td>PCB</td>
<td>IPV</td>
</tr>
</tbody>
</table>
The effects of the EC quota system on the Italian dairy market

Agricultural wages (SA) vs. Index of feed prices (IPV)
Wholesale price index for cheese (PIF) vs. Price index for milk (IPM)
Price index for imported milk (PLM) vs. Price index for imported cheese (PMF)
Consumer price index for cheese (PCF) vs. Disposable income (RD)
Index of food prices (PAA) vs. Consumer price for milk (PCL)
Consumer price for milk (PCL) vs. Per capita disposable income (RDP)
Population (N) vs. Production of long-life milk (Q)
Dummy variable 1975-1980 = 1 (D75)
Index of final agricultural product (IPV) vs. Wholesale price index (IPM)
Consumer price index (IPC) vs. EC stocks of powdered milk (SPL)
EC butter stocks (SB)
Monetary compensatory amounts (ICM)
Indicative price for milk (PIL)
Import price for milk (PLMX)
Import price for cheese (PMFX)
Trend (T)

NOTES

1. The only intervention procedures implemented have been for the storage of branded Parmesan and Grana Padano cheeses; these are to be considered as measures for price stabilization rather than price support (Cioffi, Perone-Pacifico, Polverini and Sorrentino, 1984; Rizzi and Bussi, 1972; Rizzi, 1980).
2. Statistics on the degree of significance of the model and a more detailed discussion of the hypotheses on the workings of the market together with the specification of the model are to be found in Cioffi, Perone-Pacifico, Polverini and Sorrentino (1984).
3. Reference is made to 1980 rather than to 1981 since in the latter year there was a reduction in milk supply; it would not have been possible to evaluate the effects of the introduction of the quota system with reference to 1981.
4. Under hypothesis B, in 1980 the production of milk above the imposed quota would have been about 500,000 ql., equal to 0.6% of total milk supply.

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The effect of the quota policy on the cattle stock and its composition

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Summary

The effect of the milk quota policy on the cattle stock and its composition, in the EC, is evaluated by simulation within the context of a quarterly econometric model for the European beef market. The farmers are assumed to be price-takers maximising returns from their cattle herd by deciding on its composition, by sex, and on its rate of growth through the number of total calves born.

The price-taking assumption allows us to treat the milk quota policy as equivalent to general milk price reduction. Four scenarios are entertained for our simulations; in the first a 10% permanent fall in the (real) price of milk is stipulated; the second scenario assumes that the price of milk falls initially by 10%, followed by five annual 1% reductions. The third scenario assumes that the fall in the price of milk (10%) is only temporary lasting for two years, and finally the fourth simulation is based on the assumption of a 10% permanent reduction in the 'real' price of milk, accompanied by a 10% permanent increase of the 'real' price of cereals. In all cases, the cow herd declines whilst the stock of male animals expands.

1. Introduction

The central purpose of this note is to examine the impact of the milk quota on the size and composition of the cattle stock within the EC. The EC dairy market is controlled on both the demand and supply side. On the supply side, measures to restrain the production of milk include elements of encouraging farmers to use the milk produced for alternative uses such as animal feed, and there is also...
an array of financial incentives aimed at inducing farmers to reduce the cow numbers thus restricting output, but by far the most potent type of policy that the community operates is a price policy. Since 1968 the Commission has established a 'European' milk policy which has as a cornerstone the 'target price' of milk, containing 3.7% fat. The price is an objective but not a guarantee to all farmers, however the 'target price' determines the 'intervention price' for butter and milk powder, thus if the market price for these falls below the 'intervention price' dairies/farmers are assured of receiving the intervention price for any quantity of milk they produce.

Since 1977, a 'co-responsibility levy' was imposed on the farmers, at an annual rate of 15% of the milk target price. This levy represents the first move towards the assumption by farmers of the responsibility for dairy surpluses. However it became apparent, by 1984, that these measures were inadequate to reduce the resulting surpluses, thus a super-levy was agreed, which was finally implemented by the first quarter of 1984.

On the demand side, measures aiming at increasing demand for dairy products were introduced (OECD, 1983). These measures include improved marketing, consumer subsidies, use of dairy products for animal feed by the use of subsidies and the concessionary sales of surpluses to other countries. Despite these policies, the imposition of all these measures, effecting the supply side, gave rise to the existence of substantial meat and dairy surpluses which, in the face of the budgetary crisis which is still troubling the EC, are politically and economically unacceptable. In an effort to curtail meat and dairy production, the Community decided on the imposition of a super-levy in milk production, based on a virtually zero growth policy (since 1982) for milk production, with the exception of the Irish where a 4.5% growth was allowed.

It is the outcome of the implementation of this policy that we will now turn to examine.

2. The model

In a previous paper, Arregui and Ioannidis (1984) developed and estimated a quarterly econometric model of the beef market for the EC. In this study, farmers are assumed to be price-takers and to behave as investors/producers. As investors they decide on the optimal composition of their herd by sex and age whilst as producers they decide on the rate by which they expand or contract their cattle stock by, amongst other means, the total number of calves born.

Thus we have a model of aggregate meat supply, defined as variations to the cattle stock. Producers, of a given herd size, react to relative price signals by altering the cattle stock through culling. We have two slaughtering equations, therefore, one for male and the other for female animals.

The slaughtering of animals is linked negatively to the price of adult cattle,
because as the price of adult cattle rises animals are withdrawn from culling to be fattened instead, a price increase will therefore be accompanied by a short-run decline in supply; however, in the long-run, as the herd size increases supply will expand. The farmers decision will also depend upon the opportunity cost of keeping the animals, in the case of steers, as the price of milk relative to the price of cereals (main food input) increases, slaughtering is accelerated as the positions vacated by male animals are filled by dairy cows. The opposite happens in the case of cows, here milk-price increases exert downward pressure on slaughtering.

A decision to increase the cattle stock in the context of a closed economy can only be implemented, in the long-run, by the number of the total calves born. Again farmers are assumed to respond positively to past increases in the prices of adult cattle, the relative price of milk to cereals, and of milk to compound feeding-stuff.

The supply is then closed by two identities relating the stock herds, to flows of slaughtering.

The demand side is approximated by an inverted demand function. Here the price of adult cattle responds negatively to increases in the sums of male and female animal slaughtering, and positively to the 'guide price', which acts as a price floor to real consumers expenditure, and to the price of pork which is taken to be its substitute.

The estimated model, for the period 1976:2-1982:2, with prices deflated by the CPI, is as follows, (t - statistics in parentheses)

\[
\ln (S_M)_t = 7.10 - .54 \ln (P)_{t-1} + .42 \ln (P_{ML}/P_F)_t + 1.80 \ln (H_M)_{t-1} \quad (1)
\]

\[
\ln (S_F)_t = -23.19 - .21 \ln (P)_{t-1} - .276 \ln (P_{ML}/P_F^2)_{t-1} + 2.94 \ln (H_F)_{t-1} \quad (2)
\]

\[
\ln (TCB)_t = 7.78 + .231 \ln (P)_{t-4} + .273 \ln (P_{ML}/P_F^2)_{t-3}, \quad (3)
\]

\[
\ln (\rho)_t = 3.69 - .68 \ln (S_M + S_F)_t + .97 \ln (Con)_t, \quad (4)
\]

\[
+ 0.77 \ln (P_{pig})_{t-1} + .43 \ln (P_g)_{t-1}
\]

\[
(1.5) \quad (1.5)
\]
\[ H_{Mt} = H_{Mt-1} + 0.49 \text{TCB}_t - S_{Mt} \]  
\[ H_{Ft} = H_{Ft-1} + (1 - 0.49) \text{TCB}_t - S_{Ft} \]

Where:
- \( S_M \) = male cattle slaughtering; \( S_F \) = female cattle slaughtering;
- \( \text{TCB} \) = total calves born; \( H_F \) = stock of total female cattle;
- \( H_M \) = stock of total male cattle; \( P \) = price of adult cattle;
- \( P_{ML} \) = price of milk; \( P_{Pig}^1 \) = price of cereals;
- \( P_{F}^2 \) = price of compound feeding-stuff; \( P_{g} \) = guide price for adult cattle;
- \( P_{Pig} \) = price of pigs; \( Con \) = real per capita consumption expenditure.

A detailed account of the data sources and estimation can be found in Arregui and Ioannidis (1984). The estimated coefficients have the \textit{a priori} expected signs, and they are by and large significantly different from zero.

We now turn our attention to the problem of approximating the Community's policy of milk quota within the structure of our model which is based exclusively on prices.

3. Simulations

At the roots of the existing dairy surpluses lies the price support system, which guarantees a 'high' price of milk for any quantity produced. The farmers have an incentive to produce up to the level which, with given prices, will maximize their profits, i.e. the farmers perceive that at the level of the intervention price the demand for milk is infinitely elastic.

As yields increased through better breeding, handling, feeding (high protein concentrates) and better land productivity, so did milk production, which rose by 10% in volume between 1978-1982.

On the demand side, consumption remained static. The result of these two trends was the accumulation of ever increasing dairy surpluses that were economically difficult to maintain and politically uncomfortable to dispose of. The decision was taken in 1981 to apply a levy of up to 84% of the target price in order to discourage production, but the measures were not implemented until March 1984.

The commission (E.C., 1983) was aware of an alternative policy for reducing production via the price mechanism, but it was calculated that a 12% fall in the milk price was required in order to discourage production sufficiently to meet the quota level. Although both policies can have the same outcome in terms of dairy stocks, their distributional consequences are very different. A price reduction will force inefficient farmers out of the market, and allow efficient farmers to expand. On the other hand the quota system, by keeping milk prices high will allow inefficient farmers to remain in production albeit at a smaller scale. In either case, the herd size will have to be decreased appropriately (\textit{ceteris paribus}).
If the ultimate purpose of the policy is to permanently reduce the cattle herd in the Community, in the long run, whilst reducing current dairy surpluses in the immediate future, the price reduction policy is more efficient than the quota due to the added advantage of the demand side effect, i.e. if the price falls there will be a greater demand for dairy products.

The following diagram (Figure 1) illustrates the situation in the milk market ignoring external trade. Let $P^*$ be the intervention price over and above market clearing level, $(P')$. At this price, producers will supply $q^*$ units along their supply curve (sum of $MC$ curves), as they perceive that the demand curve is $ABC$ rather than $ABD$.

The lower level part of the diagram relates the cow herd to milk production at any moment in time. Here we assume constant returns to scale. Thus there is a unique relationship between the intervention price and the size of the cow herd, $CH^*$

![Figure 1](image-url)
The imposition of a quota at $q^1$ implies that now the farmers' output reaction curve will have a vertical segment at $q^1$, $SEF$, although the interpretation of this curve as supply is problematic. Demand will remain unchanged since prices are constant, and thus the current surplus will be reduced by $q^1 - q^*$, subsequently the cow herd is going to be reduced appropriately to $CH^1$.

Now consider a price reduction policy aimed at achieving the same size of herd as the quota one: price will fall to $P^1$; producers will move along their 'supply' to $q^1$, consistent with $CH^1$, but the current addition to stocks is smaller as the quantity demanded will increase by $d^m - d^l$.

The previous analysis suggests that the milk quotas, can be considered 'equivalent' to a general milk price reduction in the sense that they both result in the same cow herd; but the added advantage of the price reduction is a considerable fall in the addition to the milk stock, due to increased consumption.

The quota policy was chosen with other considerations in mind, such as 'fairness', 'smooth adjustment of agricultural income', etc., rather than with just efficiency.

Equivalence can also be defined in terms of 'target addition to the stock', i.e. the excess of supply over demand, but if this definition was employed then the price reduction required to achieve the same level of stocks as the quota will be less than the one required to ensure cow herd equivalence; It appears to us that the problem of dairy product surpluses will only be solved, at least in the long-run, if the amount of excess capacity is reduced, and thus we will adopt the stance that the quota policy aims at permanently reducing the cow herd, whilst slowing down the fall of the farmers' revenues.

In the paper by Arregui and Ioannidis (1984), which examined the farmer's supply responses to relative prices, milk prices were assumed exogenous; this assumption is partly justified on the grounds that the rationale behind the price policy associated with the quotas have never been so explicit, and thus to endogenise milk and other prices requires the statement of the objective function of the EC policy-makers - a task beyond the scope of this paper. Here we propose to examine the effects of the milk quota, translated in real milk price reduction under four different scenarios. In the first scenario, we will assume that farmers perceive the milk quotas as a permanent decrease in the real price of milk.

In the second simulation, we assume that farmers perceive that the current quota system is only the beginning of a regime which becomes progressively stricter. To simulate this situation we assume that the real price of milk after an initial fall of 10% will continue to decline by an additional 1% annually for the next five years.

Our third scenario assumes that farmers believe that the current economic climate will not persist, and that once the budgetary crisis is over the old price regime will prevail. Here we assume that milk prices will fall by 10% in real terms for 2 years, but that they will recover to their historic level after that.

Our fourth scenario combines the reduction in the real price of milk with an
increase in the price of cereals by a equiproportionate amount, 10\%. (Although there is no evidence of such policy being implemented, it appears to be an alternative for the EC. In its effort to maintain farming incomes, the increase of cereal production at the expense of dairy products will be politically acceptable when self-sufficiency in the latter exceeds 114\%, but when it barely reaches 104\% for the former).

Graphs 1–4 present the simulation results for the four outlined scenarios. The variables are denoted as percentage differences from base run. The permanent fall in the price of milk by 10\%, will have its most immediate effect on the culling of dairy cows which increases by approximately 3\% as farmers run down their cow herds, and as beef production appears to be more profitable, the slaughtering of male animals initially declines.

![Graph 1. Permanent reduction in the real price of milk by 10%](image)

The increased slaughter of cows will initially exert a downward pressure on the price of adult cattle. The total number of calves born is predetermined but eventually declines, although its fall is halted as the price of adult cattle increases. This increase is due to the overall fall in the meat supply resulting from the accelerated slaughter of cows and by the reduction in the total number of calves born, both of which reduce the total cattle stock.

The long-run outcome of such policy will be that within 3 years of its implementation the dairy cow herd will be reduced by 2.1\% whilst the herd of steers will be 1\% above its original level.

The results of the second simulation are close to those of the first in terms of
% Deviation from Base

Graph 2. An initial reduction in the real price of milk by 10% followed by five 1% yearly additional reductions.

the direction in the movement of the relevant variables, but the long-run fall in the cow herd increases to over 3% below its original level. The immediate impact of the policy is to reduce the price of adult cattle as more cows become available for slaughtering, however this trend does not persist; within eight quarters the price has recovered to its original level. The reason for the price recovery is that the long-run supply of meat, which is proportional to the bovine herd, has been permanently reduced as both the number of calves born declines and as the returns of holding a cow decrease. This fall in the cattle stock will be partially counteracted by the increase in the male herd at the expense of the cow herd. This increase in the male animal herd is due to the fact that some agricultural capital can only be used for cattle farming, thus one would expect that as the opportunity cost of holding a male animal decreases, because of a fall in the price of milk, and so does the slaughtering. What we have here is a substitution effect of female animals for male ones induced by a change in relative returns.

If farmers perceive that the policy is a temporary one, as simulation three assumes, then, once the policy is ‘off’, after two years, all the variables return within the next 5 years to their original level leaving the stock of both male and female cattle unaffected. The lesson from this simulation is that it is imperative for the community to make abundantly clear that this policy is a permanent one, otherwise failure to convince farmers of the permanency of the policy will result in a new budgetary crisis within the next 5 years as surpluses will begin to accumulate again.

The final simulation presents a package aimed at reducing the cow herd in the
Quota policy effects on cattle stock and its composition

Graph 3. Temporary fall in the real price of milk lasting 2 years

Graph 4. Reduction in the real price of milk by 10% accompanied by an increase in the real price of cereals by 10%
first place, and at replacing milk by cereal production. Thus, the price of milk is
assumed to fall by 10% and at the same time the price of cereals increases
portionately. Here the long-run outcome is that farmers substitute out of milk/
dairy production into cereal production, therefore the total cattle stock declines
putting an upward pressure on the price of adult cattle as the supply curve has
shifted to the left. The steers/cows ratio has increased as the opportunity cost of
of a steer in terms of a cow has fallen, thus less steers are slaughtered whilst the
cow herd declines by 3% below its historical level. The effects of such policy
mimic closely those of the second simulation, but in terms of farmers' incomes
will be more favourable.

The general impression from the model is that the main reason for holding
cows in the EC is for milk rather than meat production. We expect that if
farmers are persuaded that the policy is here to stay they will reduce the dairy
cow stock by 2.25% or 1.5m animals (approx). Whether this fall will be suf-
ficient or not to avoid further budgetary crises is dependent upon the increase
in cow yields, which increased by over 16% between 1975 to 1982. If yields
increase at the same rate, it is apparent that an even stricter quota policy will
have to be implemented.

4. Conclusions

We have approximated the imposition of milk quotas by a general milk price
reduction of 10%, within the framework of a competitive model.
Within 2 years from the implementation of the policy, the steers-to-cows-
ratio increases as the stock of steers rises by 1-1.5%, whilst the cow herd
declines by 2 to 3%. There is an overall reduction in the European cattle stock
by approximately one and a quarter million animals; whether this fall will be
sufficient to permanently reduce milk surpluses depends on the milk yields.
Under historical trends, one is led to believe that further encouragement to
reduce milk production will be needed in the near future.

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Inter- and intra-sectoral effects of milk quotas in the U.K. milk industry

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Summary

The effects of milk quotas in the U.K. on farmers, their suppliers, and on the processing industries are investigated using a small econometric model. The model equations are derived from estimates of technical and economic relationships in the U.K. milk industry without an undue emphasis on an all-embracing theoretical optimization process. The model is built up from a series of individually plausible equations which, when linked together, produce simulated results for alternative farmer reactions to the imposition of quotas. Thus, reductions in herd size, reductions in cow yield, and a combination of herd and yield reductions are examined. The resulting simulations over a five year period from 1984 to 1988 illustrate changes in livestock numbers, feed demand, and income and employment in various input supply and output processing industries. These changes are of varying size and direction for different inputs and production alternatives to dairying. These results imply that it is not just the overall level of quota production that is important. The methods by which farmers adjust to the new limits are also very significant.

1. Introduction

The basis for the work undertaken for this special edition of the E.R.A.E. is the authors’ view that farm-policy changes have wider effects than are usually

* Pam Bingley is a postgraduate student financed by a Ministry of Agriculture studentship award, Michael Burton is a Research Associate engaged on a Ministry of Agriculture financed research project to model U.K. agriculture, and Dr. John Strak is a lecturer, all at the department given above.

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calculated and presented in the academic literature. Too often in the past, analyses of price and quantity decisions, guided by a concern for the detailed specifics of commodity analysis, have produced an adequate explanation of supply or demand (of a particular commodity), but have contributed little to our comprehension of the 'market' and how it works. As Thomson and Rayner (1984) and Schuh (1976) have noted, by modelling the wider effects of policy revision both analysts and practitioners of agricultural policy have much to gain. Similarly, the modelling efforts of McFall Lamm (1980) and O'Mara et al. (1984) demonstrate the benefits of analysis that links the farm sector to the macro economy.

With the introduction of milk quotas in the U.K., farmers, industry spokesmen, and politicians seem to have understood that there will be some 'knock-on' effects beyond the milk producing sector i.e. beyond dairy farmers. This provides an ideal opportunity then, for an academic comment and analysis which attempts to put right some of the omissions of previous years by modelling the dairy sector so that some of its important linkages, backwards and forwards from the farm gate are included. The vehicle or method chosen for such an investigation is that of a simulation of a system of simplified equations which represent the major relationships in what may be termed 'the milk industry'. The industry is defined as those economic and production activities relevant to producing milk from a variety of traded and non-traded inputs, and processing it for final sale to official intervention agencies — in other words, what happens on the farm, at the industry-level that supplies farms, and at the manufacturing level for milk products. The equations that are used in the model of the industry are drawn mainly from econometric estimates of technical and economic relationships, although some are created as identities from prior information. Simulations of this equation system under different assumptions about the behaviour of dairy farmers after the introduction of milk quotas provide new insights into the effects of quota controls on the U.K. dairy sector.

The basis for much of the econometrics is both empirical and structural. In other words, a time series explanation of how variables change is utilized if necessary, as is a behavioural or institutional approach when relevant. Following the arguments put forward by Taylor (1983) when describing the structuralist approach to macroeconomic modelling, the emphasis is not so much on a particular maximization process but more on judging how important decisions on, say, the number of dairy cows or milk yield are made at one level, and then describing the resulting input, output, substitution, and employment consequences of those decisions at other levels in the market. This former description (of cows and yield) is achieved by resort to easily recognized microeconomics, usually along the lines of Cowling, Metcalf, and Rayner (1970), and the latter description (of other levels in the market) is generally obtained from statistical estimates of 'predetermined', institutional or technical input-output relationships.

Implicit in all this is the view that individual agents in the market, in the long run, have only a limited awareness of the total effect of their decisions on the
wider market. Dairy farmers, for example, change production levels to hit their quota targets by reducing yields or herd size, but do not anticipate or accurately estimate the multiplier effects of their actions on feed prices, beef cow numbers, land prices, industry employment, etc. Hence, it may be more realistic for the analyst to estimate what appears to be a series of quite simple functions which, when linked together say something about the market as a whole. Whilst the purpose of the model therefore, is to formalize and quantify wider market effects over time, the approach adopted in the modelling exercise may be justified where individual economic agents (or analysts) find it difficult to perceive total effects from their own partial experiences (or their own partial comparative statics). The way in which the model is built up owes much to the Hendry type of approach described in Thomson and Rayner (1984). For each equation in the model an acceptable economic and statistical explanation is obtained from the data available by looking first at the behaviour of the data over time and then reconciling this with the appropriate theoretical constraints. In general, these 'fishing expeditions' worked quite well but it must be said that some of the final equations used in the model would benefit from further refinement. Simultaneity problems are avoided or reduced by involving both current and lagged values of explanatory variables in the model system. A simulation run of the complete system of equations should (hopefully) reproduce the dynamic behaviour of the U.K. milk industry (or demonstrate the dynamic failings of the system).

An important part of the model's structure is its ability to cope with the quantity restrictions inherent in a quota system. Just how farm production decisions are affected by this constraint is an open question. For the dairy farmer, two obvious extreme alternative reactions to quotas are (a) to reduce milk yields and allow the dairy herd to maintain its historical relationship with prices or (b) to allow yields to follow their previous (upward) pattern and reduce cow numbers accordingly. A third possibility is to combine both reactions to achieve the required quota target. The final model had to be able to cope with all of these options.

Similar difficult questions were raised about the possible effect of quotas on the cost structure of the dairy sector. If quotas are saleable, one predictable effect would be an increase in the value of quotas matched by an offsetting fall in the value of land and other production factors that have a relatively inelastic supply. If they are not saleable, the economic rent resulting from any improvement in the price of milk would be expected to manifest itself through an increase in the price of any production factors (land?) to which the quota is attached, as described by Harvey (1984). Presumably, this would have negative effects on other farm activities that compete for those production factors. The relatively simple model presented here, and the short time available for refining the model, has precluded any examination of such factor price effects.
Table 1. Estimated equations and some of the identities in the model

**Block 1: Milk production and structure**

<table>
<thead>
<tr>
<th>Model</th>
<th>Equation</th>
<th>R</th>
<th>D.h.</th>
<th>DF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scottish Dairy Herd</td>
<td>Milk production = 6.740 + [0.905 + 0.045 Dummy December] Scottish Dairy Herd(t-1) + 0.0509 Milk:Beef Returns Ratio(t-4)</td>
<td>0.929</td>
<td>1.06</td>
<td>17</td>
</tr>
<tr>
<td>Northern Ireland Dairy Herd</td>
<td>Milk production = 19.83 + [0.791 + 0.026 Dummy December] Northern Ireland Dairy Herd(t-1) + 0.127 Milk:Beef Returns Ratio(t-4)</td>
<td>0.781</td>
<td>2.78</td>
<td>17</td>
</tr>
<tr>
<td>England &amp; Wales Dairy Herd</td>
<td>Milk production = 357.44 + [0.786 - 0.0417 Dummy December] England &amp; Wales Dairy Herd(t-1) + 0.6333 Milk:Beef Returns Ratio(t-4)</td>
<td>0.761</td>
<td>0.909</td>
<td>17</td>
</tr>
</tbody>
</table>

**Block 2: Production, exports and employment in the processing sector**

<table>
<thead>
<tr>
<th>Model</th>
<th>Equation</th>
<th>R</th>
<th>D.W.</th>
<th>DF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Butter Production</td>
<td>-172.823 + 0.043 Manufacturing milk</td>
<td>0.985</td>
<td>1.298</td>
<td>10</td>
</tr>
<tr>
<td>UK Butter Exports</td>
<td>7.041 + 60.367 UK Butter Self Sufficiency</td>
<td>0.392</td>
<td>0.718</td>
<td></td>
</tr>
</tbody>
</table>

**Block 3: Traded inputs**

<table>
<thead>
<tr>
<th>Model</th>
<th>Equation</th>
<th>R</th>
<th>D.W.</th>
<th>DF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compound Feed:Milk Output Ratio</td>
<td>0.013 + 4.8*10^-6 Milk Yield - 0.006 Temp Jan + 0.007 Sun (June/July/Aug)</td>
<td>0.728</td>
<td>2.661</td>
<td>11</td>
</tr>
<tr>
<td>Log Compound Feed Price</td>
<td>-16.740 + 0.685 Log UK Dairy Herd(t-1) + 2.048 Milk Yield + 0.477 Log Barley Price(t-1) - 0.368 Log Barley Production</td>
<td>0.980</td>
<td>2.138</td>
<td>16</td>
</tr>
</tbody>
</table>
Nitrogen Fertiliser: Milk Output Ratio = 0.011 + 1.57*10^{-5} Milk Yield
\begin{align*}
(0.667) \quad (3.98)
\end{align*}
- 0.123 Compound Feed: Milk Ratio Output
\begin{align*}
(1.89)
\end{align*}

\( R = 0.543 \quad D.W. = 1.960 \quad DF = 10 \)

**Block 4: Non-traded inputs**

Artificial Inseminations = [0.275 - 0.007 Time] Average UK Dairy Herd
\begin{align*}
(36.79) \quad (3.40)
\end{align*}

\( R = 0.448 \quad D.W. = 1.320 \quad DF = 12 \)

Milking Machine Purchases = -549,500 + 0.249 Average UK Dairy Herd
\begin{align*}
(2.3)
\end{align*}

+ 86.425 Dummy 1979 - 200.120 UK Butter Self Sufficiency
\begin{align*}
(3.4) \quad (6.0)
\end{align*}

\( R = 0.851 \quad D.W. = 1.890 \quad DF = 7 \)

**Block 5: Alternative Enterprises and Production**

Northern Ireland Beef Herd = 83.680 + 0.918 Northern Ireland Beef Herd(t-1)
\begin{align*}
(3.70) \quad (25.14)
\end{align*}

- 0.253 Milk:Beef Returns Ratio(t-3)
\begin{align*}
(4.18)
\end{align*}

\( R = 0.979 \quad D.h. = 0.125 \quad DF = 18 \)

Scottish Beef Herd = 169.890 + 0.883 Scottish Beef Herd(t-1)
\begin{align*}
(3.95) \quad (14.01)
\end{align*}

- 0.425 Milk:Beef Returns Ratio(t-2)/t-3)
\begin{align*}
(5.52)
\end{align*}

\( R = 0.941 \quad D.h. = 0.038 \quad DF = 18 \)

England & Wales Beef Herd = 480.210 + 0.842 England & Wales Beef Herd(t - 1)
\begin{align*}
(5.63) \quad (16.48)
\end{align*}

- 1.299 Milk:Beef Returns Ratio(t-2/t-3)
\begin{align*}
(6.27)
\end{align*}

\( R = 0.961 \quad D.h. = -0.754 \quad DF = 18 \)

Beef Production = -2.849 + 46.085 D - 0.163 UK Dairy Herd(t-1)
\begin{align*}
(3.7) \quad (1.5)
\end{align*}

+ 0.261 UK Dairy Herd(t-3) + 0.104 UK Beef Herd(t-3)
\begin{align*}
(2.5) \quad (2.5)
\end{align*}

\( R = 0.991 \quad \rho = 0.409 \)

Clean Cattle Price/Barley Price(t-1) = 0.647 + 0.0001 \left\{ \text{Barley Production}(t-1)
\begin{align*}
(3.6) \quad (2.1)
\end{align*}

- \text{Barley Production}(t-3) \right\} - 0.0019 \left\{ \text{Beef Production}
\begin{align*}
(3.4)
\end{align*}

- \text{Beef Production}(t-1) \right\} + 0.479 \left\{ \text{Clean Cattle}
\begin{align*}
(3.4)
\end{align*}

\text{Price}(t-1)/\text{Barley Price}(t-2) \right\}

\( R = 0.967 \quad \rho = 0.398 \)

In the table above t-ratios are presented in parentheses underneath the relevant coefficient values. All equations were estimated by ordinary least squares, using the AIDA microcomputer program, except where D.W. stats and degrees of freedom are not reported. In such cases, estimation is by an autoregressive estimation procedure and the \( \rho \) value is given.
2. Estimation

The estimated equations in Table 1 are presented in five blocks. The precise boundaries of a particular block do not matter, nor does the exact situation of a particular equation in one block or another. They are there simply to help the reader understand the general concept and construction of the final model. Four categories have been chosen to reflect those areas of economic activity or decision-making that, together, are representative of ‘the milk industry’, and a fifth has been included to allow some regard to be taken of how decisions there affect other production activities and factors. This categorisation is adequate for the purposes of this paper and it is not considered necessary to enter into extensive discussion concerning the limits or constituents of each of the categories.

In the first block, that concerned with milk production and structure, the aim is to explain total milk output in the U.K. This is done using explanations of dairy herd size for England and Wales, Scotland, and Northern Ireland separately, and an estimated equation for milk yield which involves the milk/feed price ratio and a simple weather variable. The specification for the herd size equations has an economic and biological basis using a product price ratio (the milk:beef returns ratio) and lagged dependent variables. In order to increase the degrees of freedom available, the estimation here used semi-annual data which was then converted into an annual form for the simulation exercise (the semi-annual equation is converted to an annual form using a dummy variable for December). In passing, it is worth noting that the short- and long-run supply elasticities derived from these herd equations are all relatively small, having magnitudes of around 0.05. This implies, of course, that to get milk supplies reduced by an amount similar to the quota reduction using the price system would need a massive decrease in the milk price. This feature of the dairy herd equations is seen to have an important influence on the behaviour of parts of the model during the simulation exercise.

Combining the milk yield and aggregated regional herd figures gives the total U.K. milk output. The milk yield equation incorporates the one period lagged value of the milk price to try to take account of the confusion sometimes experienced by producers in knowing just what their current milk price is. Adjustments and ‘bonus’ payments at the end of the year are a common feature of the milk price calculation in the U.K. so it can be argued that producers may not accurately gauge their milk price until twelve months after any production has been sold. This lagged milk price is deflated by the current feed compound price. Technical improvements in the national herd which lead to greater milk yields per se are represented by the inclusion of a time trend.

The second block of equations deals with production, export, and employment prospects for the milk products sector. These were estimated using annual data. The estimated coefficients in the equations connecting manufactured milk with butter production and exports are intended to capture the actual technical
relationships that have occurred in historical data. There is no attempt at an economic explanation of butter production or exports. These parameter values are seen as being predetermined by the technical basis of milk processing and institutional arrangements for market support in the milk products' sector. Employment in this sector is similarly related to milk output levels, but real wages are also introduced to allow for an expected labour price effect. The relationship between employment and manufacturing milk production proved most elusive to capture. The clear upward trend in butter and skimmed milk powder production was matched by an equally clear downward trend in employment! The equation presented is the most successful obtained after a wide variety of specification alternatives had been tried.

Blocks 3 and 4 can be taken together at this point in the discussion and include key relationships on the input side of the milk producing sector. The estimations again used annual data. Block 3 equations deal with traded inputs, principally, compound feed and nitrogenous fertiliser. Block 4 is an attempt to model some of the non-traded inputs in milk production which are typically ignored in most analyses. Of the traded inputs, the quantity of nitrogen fertiliser required by the dairy sector is expected to be predetermined (in the sense that technical recommendations for the fertiliser needs of crops are known in advance) but there will also be a stochastic element in the relationship, i.e. a given level of milk production requires a certain level of fertiliser demand, but it is also influenced by random weather fluctuations. Attempts to satisfactorily involve fertilizer prices in the equation failed although milk and compound feed prices are introduced through the milk yield variable. Similarly, compound feed utilizes an economic rationale for the quantity demanded through the milk yield variable. Sunshine and temperature data were used in the equation to capture weather effects.

Insemination services and milking machine investment were chosen to represent part of the non-traded element of milk production. (Time and data constraints prevented a wider coverage of this area). The goods and, more usually, services that are associated with a domestic production industry may be termed non-traded if they do not have any significant degree of competition from overseas; their important characteristic being as Corden (1971) puts it, that they have a less than infinitely elastic industry supply curve. So, just as with land, they may be able to obtain a 'rent' from farm price and support policies in the form of increased profits, employment, etc.. Any 'service' element in the non-traded input is particularly important in that such repair, installation or maintenance requirements will have a relatively large labour requirement so if the volume of non-traded input goes up or down it is to be expected that it will have significant long-run implications for employment.

The equations given in Table 1 relate inseminations and investment to the average size of the U.K. dairy herd. For the investment equation, a dummy variable (value = 1) in 1979 is used to represent changes in the U.K. capital grant schemes which gave a once and for all boost to milking machine purchases.
around this time. The U.K.'s self-sufficiency ratio in butter production was expected to act as a proxy for loss of confidence, i.e. it was a negative confidence factor. As dairy producers saw butter production increasing and the effect of dairy surpluses on the Community's budget, they became less likely to invest in more specialized milking equipment. The size of the national dairy herd is also included as an explanatory variable on the grounds that there will be some base level of demand linked with the number of dairy cows. The equation for artificial inseminations uses the dairy herd as an explanatory variable on the same basis, and also involves a time trend to capture any shift in the calving pattern over time.

In the final block of equations, regional beef herds are estimated from semi-annual data in a similar fashion to those estimated for the regional dairy herds. Lagged dependent variables and the relative returns to milk and beef production are the explanatory variables used. Aggregation of the regional herds then produces the U.K. beef herd figure which, along with the aggregate dairy herd estimated from Block I, explains changes in beef production (i.e. meat production measured after slaughter). The negative value on the current dairy herd size and positive values on the lagged values of beef and dairy herd size are in accordance with a priori expectations about the source of beef production in the U.K. Current beef production is affected inversely by the growth of the current dairy herd (as cows are retained or culled) and positively by the supply and growth of animals derived from both breeding herds in the past. The beef production variable may also be seen as a proxy for meat slaughtering and processing capacity in the U.K. Clean cattle prices deflated by the barley price are determined by changes in barley and beef production, and by lagged values of this beef:feed price ratio.

3. Simulation

The addition of various identities and linking equations to the equations in Table 1 produced the model of the milk industry used in the simulation exercise. The simulations were carried out within part of the sample estimation period in order that the within period (1974-83) validity of the model could be checked. Then the model was run forward to 1988 on the basis of unchanged 1983 values for the exogenous variables (manufacturing and liquid milk prices, barley price, barley production, liquid milk consumption, butter disappearance, and real wage rates). This provided the base run with which to compare simulation runs which involved milk quotas in future production patterns. In the absence of clear information on how farmers would react to quotas, their behaviour under milk quotas was tested under three different assumptions. Farmers could vary either (a) their herd size, or (b) their milk yield, or (c) both, after quotas were introduced.
The first two alternatives can be thought of as representing the extremes of farmer behaviour, and should set the upper and lower bounds for any expected reactions in the simulated results. Simulation runs were made up to 1988 under these different assumptions about farmer behaviour. The identity:

\[
\text{Milk Output} = \text{Herd Size} \times \text{Milk Yield per Cow}
\]

relating dairy herd size, total milk output, and milk yield was rearranged in order to impose the milk quota and the various behavioural assumptions. In the full model, milk output was explained by herd size and milk yield together, each with their respective behavioural equations. But in the simulation run for assumption (a), milk output was given (the quota) and used with milk yield to explain herd size (the equations explaining herd size were removed from the model for this run). Similarly for assumption (b) milk yield was placed on the left-hand side of the identity and explained by milk output (the quota again) and herd size, but this time with the milk yield explanatory equation removed from the model. Any adjustment to the quota regime thus had to show itself either through the herd size or through the milk yield variable in each case. Running the model without the explanatory equations for both herd size and milk yield allowed assumption (c) to be tested as adjustment that must occur jointly across these two parameters. The method used in the model to transmit the quota effect across to the beef sector was to calculate the price change needed to produce the equivalent reduction in output in the dairy sector. This ‘quota equivalent’ change in the milk: beef returns ratio was then used in the beef herd equations to induce a response to dairy quotas in the beef sector.

The performance of the model regarding its ability to track actual values of endogenous variables over time can be assessed by simple graphical comparisons and by reference to the Theil U2 Coefficients produced as part of the output in the computer simulation package used. The advantages and disadvantages of this measure are discussed in the report of a simulation exercise by Traill (1982) and those points will not be repeated here. The criterion adopted in that report was that low values of the coefficient were preferable to high ones. An acceptable simulation should produce values of less than 1. The U2 coefficients for a range of endogenous variables of interest for the within-period simulation run of the model are listed in Table 2. Coefficients are calculated for the single equation simulation of a particular variable and for the system as a whole. As can be seen from the values in Table 2, the performance of almost all the variables are acceptable with U2 values around 1 or below 1. The exceptions to this are those equations associated with the beef herd. Fortunately, these poor results may not have a large effect on the rest of the model and so should not jeopardize the results in general, but clearly, this part of the model is not working well and needs further refinement.

The discussion of the simulation results under the three different assumptions about farmer behaviour noted above will rely mainly on Graphs 1-10 and, to a lesser extent, on final values of endogenous variables obtained from the simulation output. The emphasis of the analysis of the model results at this stage is to
Table 2. Theil $U_2^a$ coefficients

<table>
<thead>
<tr>
<th>Endogenous Variable</th>
<th>Theil coefficient</th>
<th>Single</th>
<th>System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scottish dairy herd</td>
<td>0.7763</td>
<td>0.6460</td>
<td></td>
</tr>
<tr>
<td>Northern Ireland dairy herd</td>
<td>0.6460</td>
<td>0.7490</td>
<td></td>
</tr>
<tr>
<td>England &amp; Wales dairy herd</td>
<td>0.5202</td>
<td>0.5364</td>
<td></td>
</tr>
<tr>
<td>Compound feed price</td>
<td>0.6553</td>
<td>0.5835</td>
<td></td>
</tr>
<tr>
<td>Milk yield</td>
<td>0.1210</td>
<td>0.1838</td>
<td></td>
</tr>
<tr>
<td>Feed:Milk Price ratio</td>
<td>0.0710</td>
<td>0.0665</td>
<td></td>
</tr>
<tr>
<td>Compound feed purchases</td>
<td>0.0690</td>
<td>0.1304</td>
<td></td>
</tr>
<tr>
<td>Butter exports</td>
<td>1.1400</td>
<td>0.8155</td>
<td></td>
</tr>
<tr>
<td>Butter production</td>
<td>0.0480</td>
<td>0.3055</td>
<td></td>
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<tr>
<td>Artificial inseminations</td>
<td>0.5679</td>
<td>0.6802</td>
<td></td>
</tr>
<tr>
<td>Milking machine investment</td>
<td>0.3050</td>
<td>0.3734</td>
<td></td>
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<tr>
<td>Volume nitrogen fertiliser</td>
<td>0.8230</td>
<td>0.6263</td>
<td></td>
</tr>
<tr>
<td>Scottish beef herd</td>
<td>0.8107</td>
<td>2.8568</td>
<td></td>
</tr>
<tr>
<td>Northern Ireland beef herd</td>
<td>0.9765</td>
<td>2.6938</td>
<td></td>
</tr>
<tr>
<td>England &amp; Wales beef herd</td>
<td>0.8771</td>
<td>3.8321</td>
<td></td>
</tr>
<tr>
<td>Cattle:Barley price ratio</td>
<td>0.7910</td>
<td>0.9010</td>
<td></td>
</tr>
<tr>
<td>Milk sector employment</td>
<td>0.5755</td>
<td>0.9307</td>
<td></td>
</tr>
<tr>
<td>Beef production</td>
<td>0.5740</td>
<td>0.6647</td>
<td></td>
</tr>
</tbody>
</table>

$^a$ Theil's (1966) $U_2$ coefficient has the form:

$$U_2 = \sqrt{\frac{\sum (P_t - A_t)^2}{\sum A_t^2}}$$

where $P_t$ and $A_t$ are defined as changes in predicted and actual values, respectively.

Theil's $U_2$ coefficient is used to make relative comparisons of the effects of imposing quotas rather than precise predictions of the absolute values of variables. In the graphs, the actual values are denoted by the line marked A; the within-period simulated values by the line marked SI; the constant 1983 values simulation by the line marked S2; and the simulated results from changing herd size, changing yields, and changing herd size and yields by the lines S3, S4, and S5 respectively.

Graphs 1 and 2 are concerned with the equations that were presented in Block 1 in Table 1. In Graph 1 for the national herd, the S3 line reaches the lowest values of all the simulated results and continues its downward trend throughout the simulation period. The difference between the S4 and S3 lines (the extreme options) for cow numbers is interesting. After 5 years, the dairy herd in 1988 is expected to stand at 3.4 million cows under the yield reduction simulation (about the same number as there are at the moment), and at 2.7 million cows under the herd reduction scheme. That difference of almost three
quarters of a million animals in the final year of the simulation will clearly make a difference to the demand for feed, vet services, etc. and underlines the importance of following through these different farmer reactions to see their effects on other sectors. An interesting way of assessing the results of the model is to compare the simulated herd size estimates for 1984 with the actual figure for 1984 which was reported by the Ministry of Agriculture (MAFF) after the empirical work was completed. These actual and simulated values are given below.

<table>
<thead>
<tr>
<th>1984 UK Dairy Herd</th>
<th>Difference between Actual and Simulated</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(million cows)</td>
</tr>
<tr>
<td>Actual</td>
<td>3.340</td>
</tr>
<tr>
<td>S3</td>
<td>3.060</td>
</tr>
<tr>
<td>S4</td>
<td>3.392</td>
</tr>
<tr>
<td>S5</td>
<td>3.248</td>
</tr>
</tbody>
</table>

In summary, the milk-yield reduction option seems to have been the best predictor of what actually happened to cow numbers, but both the S4 and S5 alternative reactions came quite close to the final figure.

The S4 line in Graph 2 produces the anticipated result in that it has the lowest values for milk yield but here the downward movement at the beginning of the post-quota period is lost after 1 year and the position stabilizes. The S5 line in both Graph 1 and 2 maps out a middle position in that both herd size and yield are reduced initially and then reach a new equilibrium. One interesting feature of Graph 2 is the predicted increase in milk yields if farmers only reduce cow numbers in response to the quota.

Graphs 3 and 4 are representative of Block 3 in Table 1. The compound feed purchases and compound feed price variables behave quite differently according to the assumptions about farmer behaviour used in the model simulation. Hence in Graph 3 a continuing upward trend in feed purchases is seen in the S2 and (eventually) in the S3 simulations. New lower and stable values of feed purchases are seen in S5 and S4, whereas the historical trend of feed prices is shown to be halted in the post-quota situation by the S4 and S5 lines in Graph 4. In fact these nominal price increases over time are halted simply because the values for the exogenous components of the feed compound price are held constant at 1983 values throughout the 1984–88 simulation period. The S4 and S5 simulations may thus be interpreted as real price reductions over the post-quota period (i.e. falls in price relative to the 1983 value). All the feed price simulations were done using semi-annual data and the simulated results reproduce and exaggerate the seasonal behaviour which was present in the original
Graph 1. *U.K. dairy herd ('000s cows)*

Graph 2. *Milk yield (litres per cow)*
Graph 3. Compound feed (‘000s tonnes)

Graph 4. Compound feed price index
equation. Again it is possible to look at the results for the simulations in 1984 and compare them with the actual (forecast) figures reported by the MAFF.

<table>
<thead>
<tr>
<th>1984 Compound Feed Purchases</th>
<th>Difference between Actual and Simulated</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(million tonnes)</td>
</tr>
<tr>
<td>Actual</td>
<td>4.50</td>
</tr>
<tr>
<td>S3</td>
<td>5.11</td>
</tr>
<tr>
<td>S4</td>
<td>4.78</td>
</tr>
<tr>
<td>S5</td>
<td>4.92</td>
</tr>
</tbody>
</table>

Just as with the results for the dairy herd size given above, the S4 and S5 options have percentage errors that are smaller after one year of the simulation. This may be seen as further support for the view that, in practice, U.K. dairy farmers adopted a combination of milk yield and herd size reductions rather than one or the other.

As far as feed compounders (and policy-makers) are concerned, the results over the 5-year simulation period imply that any price reductions for compound feed seen after the introduction of quotas will only be temporary under the herd size reduction option. There is also some recovery in demand for compound feed under this option after the early years of the quota. This may suggest that employment and capacity reductions in the feed compound sector will be less severe under this option in the long run. In contrast, demand for feed declines and stays at a new lower equilibrium level with no prospect of growth when milk yields are reduced. Coupling this with the end of the rising trend in feed prices seen in Graph 4 might lead to the conclusion that cereal producers should expect to depend more on intervention in the future. The expected 'shortfall' in market demand for compound feed in 1988, 5 years after milk quotas were introduced, varies between 0.8 and 1.6 million tonnes. This represents the difference between S2 and S3, and S2 and S4 feed purchase values in that year. The cumulative difference over the 5 years is obviously even larger, but the important question that policy-makers should be prepared to answer is, how will they prevent that shortfall being presented to them in the form of an increased intervention demand for feed wheat and barley? If they cannot prevent it, the model results indicate that the imposition of milk quotas in 1984 may simply have transferred the problem of surpluses from one production sector to another in the long run.

In Graph 5, the results for options (a) and (b) illustrate the different implications for sales and processing capacity in the fertilizer sector of alternative reactions to the imposition of quota. Milk yield reductions affect nitrogen usage much more than herd size reductions.

Graphs 6 and 7 are concerned with Block 4 in Table 1. In both graphs, the milk yield reduction option reduces the demand for insemination services and
investment goods the least, and the herd-culling option reduces demand the most. This latter decline in demand is in contrast to the eventual upturn in feed demand reported in Graph 3. Thus a marked contrast is seen between the growth and employment implications for different supply industries under the same assumption for farmer behaviour after quotas. Whilst the S3 line in Graph 7 should not be interpreted too literally, the reduction in herd size has an overwhelming negative effect on investment, but for the feed industry the same herd-culling alternative results, eventually, in a growth in demand for feed. A similar contrast with the feed compound sector results are seen for the milking machine purchases variable described in Graph 5. The milk yield reduction option is the most attractive for milk equipment manufacturers in that it restores investment almost to pre-1980 levels with all that that implies for income and employment in that sector. Whereas that same milk yield reduction option is seen to imply no growth and reduced demand for feed in Graph 3.

Graphs 8, 9 and 10 illustrate the results for the equations in Block 5. The poor performance of the beef herd equations in the simulation runs is seen clearly in Graph 8. The beef production figures in Graph 9 are also relatively bad given their direct dependence on beef cattle numbers. The very large increase in the size of the beef herd portrayed in Graph 8 under the dairy herd reduction option is obviously unrealistic as it would be unlikely that farmers had either the capacity, or the long-term expectations about beef returns that would encourage such a large adjustment in animal numbers. It is a weakness of the model that dairy farmers' very inelastic response to milk price changes mentioned earlier requires a very large change in the milk:beef returns ratio to produce an equivalent price effect for quotas. In turn, this large change in relative profits encourages the model's beef sector to expand very significantly. The actual and simulated results for the UK beef herd in 1984 are given below.

<table>
<thead>
<tr>
<th>1984 UK Beef Herd</th>
<th>Difference between Actual and Simulated</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(million cows)</td>
</tr>
<tr>
<td>Actual</td>
<td>1.347</td>
</tr>
<tr>
<td>S3</td>
<td>1.595</td>
</tr>
<tr>
<td>S4</td>
<td>1.212</td>
</tr>
<tr>
<td>S5</td>
<td>1.462</td>
</tr>
</tbody>
</table>

Once again, the S4 and S5 options have the smaller percentage errors and support the view that, of the three alternatives investigated, farmers have tended towards milk yield and herd size reductions jointly over the first twelve months of the quota scheme in the U.K.

Graph 10 sets out the milk sector employment implications of milk quotas in a straightforward manner. Since milk output is incorporated directly into the
Graph 5. *Volume of nitrogen fertilizer ('000s tonnes)*

Graph 6. *Artificial inseminators ('000s)*
Graph 7. Milking machines purchases index

Graph 8. U.K. beef herd ('000s cows)
Graph 9. Beef production ('000s tonnes)

Graph 10. Milk employment ('000s)
explanation of milk sector employment, it is seen that the S3, S4 and S5 options all have the same negative effect on jobs in the milk processing sector. In absolute terms this amounts to approximately 3,500 jobs lost in 1984 after quotas are introduced.

4. Concluding comments

The construction of a set of equations which represents the U.K. milk industry and which could reproduce the wider effects of milk quotas under different assumptions about farmer behaviour was the purpose and rationale for the authors' research efforts. The work done was successful in that cross-sectoral links with other input supply, processing, and production activities were estimated and built into a simulation model. Comparison of the model results with 1984 actual figures seems to suggest that U.K. farmers have not adopted a simple herd-culling reaction, but have adjusted their output levels to the quota restriction by a combination of milk yield and herd size reduction. The estimation and simulation results were constrained, however, by data problems and the ability of relatively simple specification forms to model the 'real world'. These are two areas in which more research and work needs to be done. The equation system also needs to become more 'closed' so that the feedbacks and interrelationships of the markets are better represented and extended to allow more links with the rest of the economy.

The limited model results presented here do illustrate some significant differences for farmers and their suppliers of alternative reactions to milk quotas. These differences must be analysed further if the quota policy implemented to reduce milk surpluses is not to produce harmful 'knock on' effects in other industries. The implications for employment in agriculturally-based rural industries, for example, are likely to vary according to these reactions. Similarly, policy-makers have a very real interest in knowing what effect milk quotas may have on other production sectors and on, say, cereal support policies. As it was, milk quotas were agreed by the Council of Ministers without an understanding of what their wider effects might be and with no guidance as to what was the 'best' option for producers' adjustment to the new policy. That ignorance may have been excused at the time by the political background to the adoption of quotas. The work done and results that form the basis for this contribution to the E.R.A.E. support the contention that there is a method available for understanding the multiplier effects of quotas in the dairy sector, and that such an understanding is demonstrably important for farmers, input suppliers, processors, and policy-makers alike, now that quotas are part and parcel of the CAP.
REFERENCES

A super-levy system for the dairy sector: Consequences and alternatives

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Department of Agricultural Economics, Agricultural University, Wageningen, Netherlands

Summary

The policy decision to introduce a super-levy system for the dairy sector of the EC is compared with two alternatives: a restrictive price policy coupled with a considerable co-responsibility levy, and a policy with a large decrease in milk price together with direct income transfers for dairy farmers. A benchmark policy, defined as the continuation of the dairy policy used during the period 1976-1983, functions as a basis for comparison with these policy alternatives over the period 1984-1988. Next, the article considers what the result of a policy change starting in 1977 would have been. The periods 1977-1983 and 1984-1988 are dealt with separately. The total effect (over the period 1977-1988) of more appropriate policy decision-making is estimated to be 20 milliard ECU's for budget costs and 10 milliard ECU's for EC income.

In the last part of the article, the consequences for the Netherlands have been investigated. Here, the somewhat different position of this country becomes clear.

1. Introduction

Ever since its establishment in 1968, the EC dairy market has experienced problems. Sometimes, a policy change seemed inevitable, at other times, the problems of the dairy market appeared to be less acute and dairy policy remained unchanged, but the income of dairy farmers received more attention. However, during the period 1968-1983 the basic principles of EC dairy policy were not changed, except by the introduction of a co-responsibility levy in 1977.

* Mrs. J. Burrough-Boenisch improved the English of this article.
The introduction of the super levy in April 1984 was a fundamental change in EC dairy policy. Although the policy for the demand side of the market remained unaltered, the supply side changed from a free market system to a quota system. The consequences of that decision can be clarified by studying the alternative policies available at that time, of which there were several, each with many variations. The main three alternatives were:

1. a very restricted price policy and a high co-responsibility levy,
2. a price decrease with income allowances, and
3. the quota (or super levy) system that was, in the event, opted for.

To calculate the effects of the different policy alternatives, a model of the EC dairy market (and the Netherlands dairy market) is necessary. Such a model has been developed in the last seven years. Basically, it is a policy-oriented computer model that calculates the effects of nearly every type of dairy policy. The effects have not been limited to the usual categories of economic analysis (income, consumer expenditure, budget) but are also concerned with a broad spectrum of policy aims at EC or national level. In this paper, however, it is most relevant to highlight the typical economic variables incorporated in the model, see Oskam (1981 and 1986a). In this article only some basic elements, large number of additional elements. For a more detailed description of the model, see Oskam (1981 and 1985a). In this article only some basic elements, related to the different policy alternatives and, in particular, to the super levy system, will be dealt with.

The effects over the 5-year period 1984-1988 of the three policy alternatives mentioned above will be investigated. I have formulated the first two alternatives in such a way that in the period 1984-1988 the total budget costs are equal to those of the super levy option. Given the difficulties in balancing the EC budget, that seems an obvious point. Each policy alternative will be compared with a benchmark alternative — i.e. a continuation, during the period 1984-1988, of the policy that was in operation during the years 1976-1983. Next, the same types of alternatives will be handled in an ex-post policy analysis of the period 1977-1983. The results indicate what would have happened if politicians had acted more positively to control the market. For the analysis, it is important that a policy change in 1977, also has implications for the period 1984-1988.

The last part of the analysis ascertains the effects of the super levy for the Netherlands. The same calculations have been made as for the EC. The results for the Netherlands will be presented in resume form.

2. The policy alternatives

The benchmark policy alternative (i.e., the unmodified policy) serves as a basis for comparison. For some variables, it is difficult to present results in absolute
values and therefore comparisons are necessary. Moreover, the benchmark policy alternative also shows what the results of continuing the dairy policy during the period 1976-1983 would be. The policy instruments (e.g. export restitutions, subsidies) that have been assigned to all policy alternatives were chosen in accordance with the traditions of EC dairy policy. More information on the make-up of the policy alternatives can be found in Tables 1 and 2.

The super-levy system is exactly the type of policy followed since April 1984. The policy instrument values in 1984 used in my assessment are actual values. For the period after 1984, some assumptions have had to be made (see Tables 1 and 2): the demand side of the dairy market remains unaltered but, since milk

Table 1. Information about policy alternatives over the period 1984-1988

<table>
<thead>
<tr>
<th>Variable/Parameter</th>
<th>Benchmark Policy Alternative</th>
<th>Super Levy</th>
<th>Price Decrease and Co-responsibility Levy</th>
<th>Price Decrease and Income Allowances</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual change of real milk price (%)</td>
<td>-2</td>
<td>see Table 2</td>
<td>-2(-6)(^a)</td>
<td>-1(-17)(^a)</td>
</tr>
<tr>
<td>Co-responsibility levy (%)</td>
<td>2</td>
<td>see Table 2</td>
<td>4</td>
<td>-</td>
</tr>
<tr>
<td>Annual shift of supply curve (or marginal cost curve) in %</td>
<td>3.8</td>
<td>2.2</td>
<td>3.8</td>
<td>3.3</td>
</tr>
<tr>
<td>Export restitution(^b)</td>
<td>38</td>
<td>see Table 2</td>
<td>38</td>
<td>38(^c)</td>
</tr>
<tr>
<td>Subsidy skimmed milk (powder) for calves(^b)</td>
<td>42</td>
<td>see Table 2</td>
<td>42</td>
<td>42</td>
</tr>
</tbody>
</table>

\(^a\) In parentheses: price change in 1984
\(^b\) In % of the intervention price
\(^c\) Lower restitution in 1987 and 1988 as a result of the market situation

Table 2. Specific information about policy alternatives over the period 1984-1988

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>All alternatives:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>disposal of butter stocks</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(1000 tons)</td>
<td>-210</td>
<td>250</td>
<td>200</td>
<td>250</td>
<td>150</td>
</tr>
<tr>
<td>disposal of skimmed powder stocks</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(1000 tons)</td>
<td>220</td>
<td>300</td>
<td>200</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>Super levy:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>milk quota (million ton)</td>
<td>100.5</td>
<td>98.8</td>
<td>98.5</td>
<td>98.5</td>
<td>98.5</td>
</tr>
<tr>
<td>annual change of real milk price (%)</td>
<td>-3</td>
<td>-2</td>
<td>0</td>
<td>-1</td>
<td>-1</td>
</tr>
<tr>
<td>co-responsibility levy (%)</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>export restitution (%)</td>
<td>40</td>
<td>40</td>
<td>38</td>
<td>35</td>
<td>35</td>
</tr>
<tr>
<td>subsidy skimmed milk (powder) for calves</td>
<td>45</td>
<td>45</td>
<td>42</td>
<td>42</td>
<td>42</td>
</tr>
</tbody>
</table>
production is lower than in the benchmark policy and milk prices are also different, the prices for dairy products and the amounts consumed will differ from those of the benchmark policy alternative.

The European Commission’s proposal for a super levy was accompanied by the observation that without such a levy, an important price decrease was inevitable. (Commissie, 1983: 16). Here, I will investigate the effects of such a price decrease plus a higher co-responsibility levy. Although a co-responsibility levy of more than 4% of the target price is not allowed under regulation 77/1079, such a regulation could be changed. Further details about this policy alternative are given in Tables 1 and 2.

The last policy alternative is a price decrease accompanied by direct income payments. Such a policy has been proposed and/or investigated by Van Riemsdijk (1973), Koester and Tangerman (1976), and, more specifically for the dairy sector, by a study group on dairy policy (Interim-rapport, 1978) and Hanf and Koester (1980). The disconnection between the market equilibrium function and the income function of prices is central to this alternative. Because of the budget limitation, the income effect of the price decrease is only partly compensated for by income allowances.

3. The EC dairy model: some principles

The EC dairy model has been based on supply and demand functions. These functions have been formulated on the basis of relevant research results (Interim-rapport, 1978, Appendices B and C; Commission, 1981; Oskam and Ozinga, 1982). The supply side of the model has the following general formulation:

\[ Q_t = c_t \prod_{i=0}^{I} P_t^{\alpha i} \]  

(1)

where

- \( Q \) = quantity of milk (milk delivered plus human consumption directly from the farm)
- \( P \) = real milk price; this is the price at the level of butter and skimmed milk powder
- \( c \) = shift factor of the supply function.
- \( I \) = total period (in years) for which prices influence production
- \( t \) = time subscript

The shift factor \( c_t \) forms a central element of the supply function; \( c_t \) can be influenced by:

- prices of inputs and outputs
- policy measures, e.g. quota systems, subsidies for investments, income allowances.

This implies that the development of \( c_t \) can be the result of many factors that
influence milk production. Equation (1) can also be interpreted as the reduced form equation of a larger model (Oskam, 1986b).

The parameter values used in the EC dairy model are shown in Table 3. Price elasticities of supply have been based on the literature (Askari and Cummings, 1976; Interim-rapport, 1978; Commission, 1981) and on personal research (Oskam and Osinga, 1982; Oskam, 1986b). The value for the development of the shift factor \( = c_t/c_{t-1} \) has been derived from actual values of milk production and farm milk prices for the EC. A shift factor of 1.038 has been calculated over the period 1976-1982. An annual change in \( c_t \) of 3.8% implies that milk production will increase by 3.8% if real milk prices remain constant. The same shift factor has been used for the benchmark policy alternative over the period 1984-1988. Furthermore, it is assumed that a large price decrease will restrain the annual shift to 3.3%. Because income allowances will be mainly given to small dairy farmers, the liquidity situation of the main producers limits investments in new technology. Under the super-levy system a 2.2% annual shift of the supply function (marginal cost function) has been assumed (see Table 1).

Table 3. Parameter values and variables for supply function of the EC and Netherlands dairy model

<table>
<thead>
<tr>
<th>Parameters/Variables</th>
<th>EC</th>
<th>Netherlands</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price elasticities; year 0 ((i=0))</td>
<td>0.10</td>
<td>0.15</td>
</tr>
<tr>
<td>&quot; 1</td>
<td>0.25</td>
<td>0.25</td>
</tr>
<tr>
<td>&quot; 2</td>
<td>0.20</td>
<td>0.15</td>
</tr>
<tr>
<td>&quot; 3</td>
<td>0.20</td>
<td>0.20</td>
</tr>
<tr>
<td>&quot; 4</td>
<td>0.10</td>
<td>0.10</td>
</tr>
<tr>
<td>&quot; 5</td>
<td>0.08</td>
<td>0.05</td>
</tr>
<tr>
<td>&quot; 6</td>
<td>0.07</td>
<td>0.05</td>
</tr>
<tr>
<td>years 7-10</td>
<td>0.05</td>
<td>0.05</td>
</tr>
<tr>
<td>Shift of supply function for benchmark policy ((% \text{ per year}))</td>
<td>3.8</td>
<td>6.4</td>
</tr>
<tr>
<td>Milk price in 1982 ((\text{ECU/ton}))</td>
<td>321</td>
<td>332(^{a})</td>
</tr>
<tr>
<td>Quantity of milk in 1982 ((\text{million tons}))</td>
<td>106.0</td>
<td>13.1(^{a})</td>
</tr>
</tbody>
</table>

\(^{a}\) Values for 1983

2.1. Calculation of cost differences

According to general economic theory, marginal cost functions are derived from supply functions, defined with the same time-lag. Thus, a marginal cost function is the inverse of a supply function. This holds under the assumption that producers are free to choose their production level and that they sell at the same market price. However, under a super-levy system there is a large price difference
between milk that falls within the quota and milk that exceeds the quota. Therefore, marginal cost differences cannot be derived directly from the supply function.

The principles of calculating cost differences under a super-levy system (compared with a price policy without a super levy) have been illustrated in Figure 1. In that figure, the super-levy system is coupled with a decrease in the price of milk. Without the quota, a price decrease of milk from $P_1$ (the price in the benchmark policy alternative) to $P_2$ would result in a production level $Q_2$. The quantity of milk not liable to a super levy is $Q_3$. The comparison of the super levy alternative with the benchmark alternative results in areas $a-f$ being distinguished in Figure 1.

![Figure 1](image)

**Figure 1.** Analysis of effects on producers' income and production costs of a super-levy system, vis-à-vis the benchmark policy alternative

**Notes:**

$a =$ cost difference resulting from a price decrease that causes a fall in production from $Q_1$ to $Q_2$

$b =$ income difference caused by that price change

$c =$ income loss caused by a super levy, distributed, according to the marginal cost function, among the high-cost producers, or absorbed by high-cost production

$d =$ additional income loss caused by the actual distribution of milk – not subject to the super levy – among the dairy farmers

$e =$ cost difference caused by a drop in production necessitated by the super levy

$f =$ increase of marginal costs per unit of production, caused by different rate of technological change under a super-levy system.
Total effect on producers' income is \( -(b + e + d + f) \), whereas total cost difference for milk production is \( -a - e + f \).

The relative importance of these different areas, as shown by the EC dairy model, has been illustrated in Table 4. The actual values strongly depend on the exact formulation of the super-levy system and on the period analysed. Over time, area \( f \) becomes increasingly important. Of course, \( d \) and \( f \) depend on how the quota is distributed among dairy farmers. For a non-tradeable quota, \( d \) and \( f \) will become more important than for an easily tradeable quota. However, even under the present EC system, I have estimated that \( d \) and \( f \) will be relatively small, even by 1988.

Table 4. Relative importance of different areas in Figure 1 in percentages of total revenue under the benchmark policy alternative

<table>
<thead>
<tr>
<th>Area</th>
<th>Description</th>
<th>1984</th>
<th>1988</th>
</tr>
</thead>
<tbody>
<tr>
<td>( a )</td>
<td>Cost difference because of price change</td>
<td>0.2</td>
<td>-1.0 (^\text{a})</td>
</tr>
<tr>
<td>( b )</td>
<td>Income ( &quot; ) ( &quot; ) ( &quot; ) ( &quot; ) ( &quot; )</td>
<td>1.9</td>
<td>-4.1 (^\text{a})</td>
</tr>
<tr>
<td>( c )</td>
<td>Income loss super levy (minimum)</td>
<td>0.8</td>
<td>1.1</td>
</tr>
<tr>
<td>( d )</td>
<td>Additional income loss super levy</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>( e )</td>
<td>Cost difference because of super levy</td>
<td>3.4</td>
<td>13.8</td>
</tr>
<tr>
<td>( f )</td>
<td>Increased marginal costs</td>
<td>0.5</td>
<td>3.0</td>
</tr>
</tbody>
</table>

\(^\text{a}\) Negative sign because milk price is higher under the super-levy system

2.2. Demand side of the EC dairy model

The demand side of the model consists of different markets, e.g., internal market with normal prices, commercial export market, food aid, and the subsidized internal market. Imports of dairy products also form part of the demand side. For each market, there are a number of relevant dairy products. In all, about 20 to 30 demand functions have been incorporated in the model. The number of functions depends on the market and price policy of the EC. Some functions (food aid, imports) are completely inelastic. Others have normal slopes, and demand for dairy products at feed-price level is very price elastic. Furthermore, some subsidized products replace normally priced products (see Meester and Oskam, 1983, and Meester and Oskam, 1984, for an explanation of the theory of replacement).

Every type of dairy product has been characterized by its contents of fat component and skimmed milk component. By definition, 1 kg milk of average composition \( Q^m \) is equal to 1 kg of fat component \( Q^{fc} \) and 1 kg of skimmed component \( Q^{skc} \). Therefore:

\[
1 \text{ kg } Q^m = 1 \text{ kg } Q^{fc} + 1 \text{ kg } Q^{skc}
\]
Now, every dairy product can be considered as a combination of fat component and skimmed component. Cream, for example, has the following composition:

\[ 1 \text{ kg cream} = 8.37 \text{ kg } Q^{ic} + 0.7 \text{ kg } Q^{ke} \]  

(3)

The price relation between fat component and skimmed component is basically ruled by the intervention prices for butter and skimmed milk powder. From that price relation the value share of fat component \((= s_f)\) and skimmed component \((1-s_f)\) in milk can be derived; furthermore, every dairy product can be interpreted as a quantity of milk equivalent units. Therefore:

\[ 1 \text{ kg cream} = s_f \cdot 8.37 + (1-s_f) \cdot 0.7 \text{ kg milk equivalent} \]  

(4)

In the course of time the milk equivalent units of a dairy product can change because of:
- a change in the composition of milk used for that dairy product, e.g. higher fat content
- a change in composition of the dairy product
- more efficient manufacturing of dairy products from milk
- a different price share of fat component and skimmed component.

The milk price has been taken at the level of butter and skimmed milk powder: this is the price of milk with average fat content. All prices of dairy products can be derived from this milk price if their composition is known. The price levels of butter and skimmed milk powder have been fixed at such a level that, after removing transport and processing costs, one is left with the average farm price. The information used in the demand side of the model is shown in Table 5. An additional factor influencing the outcome of the analysis is the stocks of butter and skimmed milk powder. These stocks can be increased or decreased by government policy.

Given these characteristics of supply and demand functions, the effects on producers’ income, consumers’ income and the EC budget were calculated following the usual procedure in welfare economics (e.g. see Just et al., 1982). Here an additional remark seems interesting. If resources, originally (or under a different policy) used in the dairy sector, shift to other products, the EC model does not incorporate budget effects for those products. The same holds if more resources were to be used in the dairy sector: decreasing budget costs for other products have not been included. The effects on EC income, defined as the sum of national incomes of the member states, is the algebraic sum of effects on producers’ income, consumers’ income and budget. However, in the model, the effect on EC income was also calculated directly from cost differences on the supply side and differences in willingness to pay on the demand side. This slight difference in calculation method leads to a minor discrepancy with the results obtained by the above-mentioned algebraic sum.
Table 5. General information used for the demand side of the EC model<sup>a,b</sup>

<table>
<thead>
<tr>
<th>Product</th>
<th>Reference Quantity 1982</th>
<th>Price Elasticity of Demand</th>
<th>Trend in Consumption</th>
<th>Reference Quantity 1982</th>
<th>Export Restitution</th>
<th>Price Elasticity of Demand</th>
<th>Trend in Demand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk and milk products</td>
<td>27670</td>
<td>-0.125</td>
<td>-0.5</td>
<td>-</td>
<td>-</td>
<td>-1.2</td>
<td>3</td>
</tr>
<tr>
<td>Cream</td>
<td>735</td>
<td>-0.25</td>
<td>1.0</td>
<td>-</td>
<td>-</td>
<td>-1.7</td>
<td>1</td>
</tr>
<tr>
<td>Cheese</td>
<td>3770</td>
<td>-0.4</td>
<td>1.5</td>
<td>382</td>
<td>42</td>
<td>-1.1</td>
<td>1</td>
</tr>
<tr>
<td>Butter</td>
<td>1640&lt;sup&gt;d&lt;/sup&gt;</td>
<td>-0.5</td>
<td>-2.0</td>
<td>346</td>
<td>42</td>
<td>-1.1</td>
<td>2</td>
</tr>
<tr>
<td>Condensed milk</td>
<td>885</td>
<td>-0.2</td>
<td>-1.0</td>
<td>520</td>
<td>35</td>
<td>-1.1</td>
<td>1</td>
</tr>
<tr>
<td>Unskimmed milk powder</td>
<td>197</td>
<td>-0.2</td>
<td>0</td>
<td>458</td>
<td>35</td>
<td>-1.1</td>
<td>2</td>
</tr>
<tr>
<td>Skimmed milk powder</td>
<td>207</td>
<td>-0.2</td>
<td>0</td>
<td>153</td>
<td>35&lt;sup&gt;e&lt;/sup&gt;</td>
<td>-1.4</td>
<td>1</td>
</tr>
<tr>
<td>Casein</td>
<td>50</td>
<td>-0.2</td>
<td>-0.5</td>
<td>49</td>
<td>-</td>
<td>-1.4</td>
<td>1</td>
</tr>
</tbody>
</table>

<sup>a</sup> Excluding food aid, imports and some special subsidized products. During the period 1984-1988 annual food aid is 150 thousand tons of skimmed milk powder and 45 thousand tons of butter oil; imports are 100 thousand tons of cheese and 90 thousand tons of butter. Skimmed milk powder for calves in the reference year is the most important subsidized product (1400 thousand tons including skimmed milk).

<sup>b</sup> In 1982, the reference milk price (i.e. price of butter plus price of skimmed milk powder) was 320 ECU/ton. In ECU's of 1983 this would be 332 ECU/ton.

<sup>c</sup> Annual increase of population: 0.1%

<sup>d</sup> Partly subsidized; reference quantity at normal price level is 1500 thousand tons.

<sup>e</sup> A subsidy given for skimmed milk used for casein.
4. Results for the policy alternatives over the period 1984–1988

The benchmark policy alternative and the three other alternatives were defined in Section 2. Table 6 presents the results of the calculations. Because the figures for producers' income, consumers' income and EC income are relative numbers (compared with the benchmark policy alternative), the results for those variables are shown only for the three alternatives investigated.

Table 6. Effects on producers' income, consumers' income and EC income for three policy alternatives (vis-à-vis the benchmark policy alternative) and budget costs for all policy alternatives. (All amounts are in milliard ECU's of 1983)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Producers' income</td>
<td>1984</td>
<td>-</td>
<td>-1.5</td>
<td>-3.1</td>
<td>-4.1</td>
</tr>
<tr>
<td></td>
<td>85</td>
<td>-</td>
<td>-1.2</td>
<td>-2.7</td>
<td>-3.8</td>
</tr>
<tr>
<td></td>
<td>86</td>
<td>-</td>
<td>-0.7</td>
<td>-2.3</td>
<td>-3.6</td>
</tr>
<tr>
<td></td>
<td>87</td>
<td>-</td>
<td>-0.2</td>
<td>-2.0</td>
<td>-3.3</td>
</tr>
<tr>
<td></td>
<td>88</td>
<td>-</td>
<td>-0.1</td>
<td>-1.6</td>
<td>-3.1</td>
</tr>
<tr>
<td>Consumers' income</td>
<td>1984</td>
<td>-</td>
<td>0.3</td>
<td>1.4</td>
<td>4.7</td>
</tr>
<tr>
<td></td>
<td>85</td>
<td>-</td>
<td>0.3</td>
<td>1.2</td>
<td>4.4</td>
</tr>
<tr>
<td></td>
<td>86</td>
<td>-</td>
<td>-0.3</td>
<td>0.9</td>
<td>4.2</td>
</tr>
<tr>
<td></td>
<td>87</td>
<td>-</td>
<td>-0.5</td>
<td>0.6</td>
<td>3.9</td>
</tr>
<tr>
<td></td>
<td>88</td>
<td>-</td>
<td>-0.8</td>
<td>0.3</td>
<td>3.6</td>
</tr>
<tr>
<td>Budget costs</td>
<td>1984</td>
<td>6.5</td>
<td>4.5</td>
<td>4.2</td>
<td>5.6</td>
</tr>
<tr>
<td></td>
<td>85</td>
<td>8.2</td>
<td>5.4</td>
<td>5.4</td>
<td>6.0</td>
</tr>
<tr>
<td></td>
<td>86</td>
<td>7.9</td>
<td>4.7</td>
<td>4.9</td>
<td>4.7</td>
</tr>
<tr>
<td></td>
<td>87</td>
<td>7.9</td>
<td>4.8</td>
<td>4.8</td>
<td>3.8</td>
</tr>
<tr>
<td></td>
<td>88</td>
<td>7.4</td>
<td>4.1</td>
<td>4.4</td>
<td>3.1</td>
</tr>
<tr>
<td>EC income</td>
<td>1984</td>
<td>-</td>
<td>0.9</td>
<td>0.6</td>
<td>1.4</td>
</tr>
<tr>
<td></td>
<td>85</td>
<td>-</td>
<td>1.9</td>
<td>1.1</td>
<td>2.6</td>
</tr>
<tr>
<td></td>
<td>86</td>
<td>-</td>
<td>2.2</td>
<td>1.4</td>
<td>3.3</td>
</tr>
<tr>
<td></td>
<td>87</td>
<td>-</td>
<td>2.4</td>
<td>1.7</td>
<td>4.2</td>
</tr>
<tr>
<td></td>
<td>88</td>
<td>-</td>
<td>2.5</td>
<td>1.7</td>
<td>4.4</td>
</tr>
</tbody>
</table>

The budget costs of EC dairy policy are given in absolute numbers. The three policy alternatives have nearly the same level of budget costs over the period 1984–1988 as stipulated in Section 1. The conclusions that can be drawn about the three policy alternatives are:

1. The super-levy system induces a rapid decrease in budget costs. This is because, compared with a general price decrease, a super-levy system in-
fluences milk production more effectively. This could be one of the reasons for using a super-levy system or a high co-responsibility levy in a situation characterized by a substantial budget deficit.

2. Compared with a price decrease plus co-responsibility levy and a price decrease plus income allowances, a super-levy system leads to a higher income level for dairy producers.

3. A price decrease plus income allowances is the most preferable alternative from the consumer's point of view. The super-levy system imposes the greatest burden on the consumer. This is a well-known property of quota systems.

4. All three policy alternatives influence EC income in the same direction. This clearly shows that in a strong disequilibrium situation, as in the case of the EC dairy market, it is more important to decrease milk production than to use policy instruments that are optimal from the point of view of allocation. The fact that a price decrease with income allowances leads to the highest EC income is due both to the important reduction of milk production and to a better allocation of milk and dairy products among different markets. With a super-levy system, nearly the same effect could be reached. Of course, this conclusion only holds for the period 1984–1988. After that period, the fact that under a super-levy system the production structure changes more slowly can become more important.

Although the EC dairy model also generates the effects on other policy aspects, e.g. ease of administration, income distribution of dairy farmers, international trade, etc. (see Oskam, 1981: 31), these results have been omitted, for reasons of space. However, attention was focused on the income of dairy farmers. If it is assumed that:

- a change in the producers’ income results in a change in the dairy farmers’ income only^3
- in the benchmark policy alternative, the income of dairy farmers forms 40% of the gross revenue of the producers^4

then the relative income levels of dairy farmers can be calculated for the different policy alternatives (see Figure 2).


The policy alternatives formulated in Section 2 could have been introduced in 1977 instead of in 1984, because, in 1976, the European Commission had already signalled that there were major problems facing the dairy market. The Action Programme on dairy policy (Commission, 1976) was based on an analysis of the EC dairy market, for which growing surpluses were expected. Although the measures proposed in that programme were completely inadequate for solving the problems of surpluses (Oskam, 1981: 4, 5), at that time there was no
lack of proposals for an effective change of policy (Van Riemsdijk, 1973; Koester and Tangermann, 1976; Uri, 1971). Therefore, for the purposes of the present analysis, I formulated some policy alternatives along the same lines as described in Section 2. These policy alternatives are:

1. Benchmark policy alternative: this is the actual dairy policy over the period 1977-1983.
2. Super-levy system: here a super levy is introduced with the 1975 milk production per country as the reference level; total production quota increases by 0.5% per year. The annual real milk price change is -1%.
3. Price decrease and co-responsibility levy: real price decrease of 5% in 1977, together with a co-responsibility levy of 4% and an annual change of -2% in the real price of milk.
4. Immediate price decrease of 12%, partly compensated for by direct income transfers. Later, a real milk price change of -2% per year.

For policy alternatives 2, 3 and 4, several instruments (subsidies, restitutions) have been adjusted to the new market situation. However, imports of dairy products and food aid have been assumed to remain at the same level.

First, an ex-post calculation of actual dairy policy was done (see Table 7). The result obtained was compared with actual values of production, consumption, exports and budget costs. The results obtained from the model correspond well with actual values for production and human consumption. However, exports are too small in the model. The difference in budget costs can be attributed to the under-estimation of exports in the model.
Table 7. A comparison of model values (M) and actual values (A) for the EC dairy market (1977-1983). (quantities in million tons of milk (equivalent); budget costs in milliard 1983 ECU’s)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Production M</td>
<td>95.2</td>
<td>98.5</td>
<td>100.9</td>
<td>103.0</td>
<td>104.1</td>
<td>105.3</td>
<td>106.9</td>
</tr>
<tr>
<td>Production A</td>
<td>93.9</td>
<td>97.9</td>
<td>100.2</td>
<td>102.1</td>
<td>102.6</td>
<td>105.9</td>
<td>109.9</td>
</tr>
<tr>
<td>Total human consumption^a</td>
<td>M 69.8</td>
<td>71.0</td>
<td>71.9</td>
<td>73.9</td>
<td>74.2</td>
<td>74.3</td>
<td>75.4</td>
</tr>
<tr>
<td>Export^b</td>
<td>A 71.4</td>
<td>71.1</td>
<td>73.1</td>
<td>73.1</td>
<td>74.1</td>
<td>74.3</td>
<td>-</td>
</tr>
<tr>
<td>Exports M</td>
<td>7.5</td>
<td>9.1</td>
<td>9.2</td>
<td>9.6</td>
<td>9.3</td>
<td>8.5</td>
<td>8.9</td>
</tr>
<tr>
<td>Exports A</td>
<td>9.8</td>
<td>8.0</td>
<td>12.4</td>
<td>15.6</td>
<td>14.3</td>
<td>12.0</td>
<td>11.2</td>
</tr>
<tr>
<td>Budget costs M</td>
<td>6.7</td>
<td>5.8</td>
<td>7.7</td>
<td>6.8</td>
<td>5.8</td>
<td>4.6</td>
<td>4.4</td>
</tr>
<tr>
<td>Budget costs A</td>
<td>5.0</td>
<td>6.3</td>
<td>6.5</td>
<td>6.1</td>
<td>4.0</td>
<td>3.6</td>
<td>4.4</td>
</tr>
</tbody>
</table>

^a Internal human consumption, corrected for special arrangement butter and Christmas butter and use of casein.  
^b Excluding food aid and special export of skimmed milk powder.

Table 8. A comparison of four alternative dairy policies in the period 1977-1983. (aggregated data in milliard 1983 ECU’s)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Producers' income</td>
<td>-</td>
<td>3.1</td>
<td>-10.2</td>
<td>-7.6</td>
</tr>
<tr>
<td>Consumers' income</td>
<td>-</td>
<td>-8.4</td>
<td>4.0</td>
<td>15.0</td>
</tr>
<tr>
<td>Budget</td>
<td>37.9</td>
<td>21.8</td>
<td>24.2</td>
<td>30.5</td>
</tr>
<tr>
<td>EC income</td>
<td>-</td>
<td>9.5</td>
<td>6.8</td>
<td>13.4</td>
</tr>
</tbody>
</table>

The results of the policy analysis for the period 1977-1983 have been summarized in Table 8. Because the interpretation of the results is similar to the interpretation of Table 6 and Figure 2, only the conclusions will be discussed.

- The dairy policy actually followed during the period 1977-1983 resulted in lower producers' income than would have been the case under a super-levy system.
- The dairy policy actually pursued gave higher budget costs than any of the three policy alternatives. If a super-levy system had been introduced in 1977, about 16 milliard ECU’s would have been saved during the period 1977-1983.
- Compared with the policy actually pursued, each policy alternative would have saved 7 to 13 milliard ECU’s of EC income.

However, the benefits of a policy change in 1977 do not terminate after 1983.
The policy actually pursued led to investments and more resource use in the dairy sector, and in terms of the EC, economy dairy farmers developed their production in a misguided direction. This means that it was very difficult to decrease milk production in 1984 and later to the level of production that would have been reached if a super-levy system had been introduced in 1977. The results of an analysis of the consequences of introducing a super-levy system in 1977 compared with the consequences of introducing such a system in 1984 are shown in Table 9. Here too, it is clear that after a period of 7 years, the difficulties of structural change consequent on a super-levy system do not offset the advantages of having no or limited surpluses. However, with a super-levy system, the consumers tend to pay more for 'normal-priced' dairy products. The total effect (over the period 1977-1988) of more adequate policy decision-making was estimated as being 20 milliard ECU's for budget costs and 10 milliard ECU's for EC income. These are considerable amounts.

Table 9. The effects of introducing a super-levy system in 1977 compared with the effects of introducing a super levy in 1984

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Producers' income</td>
<td>3.1</td>
<td>5.1</td>
<td>8.2</td>
</tr>
<tr>
<td>Consumers' income</td>
<td>-8.4</td>
<td>-8.2</td>
<td>-16.6</td>
</tr>
<tr>
<td>Budget costs</td>
<td>-16.1</td>
<td>-4.5</td>
<td>-20.6</td>
</tr>
<tr>
<td>EC income</td>
<td>9.5</td>
<td>1.5</td>
<td>11.0</td>
</tr>
</tbody>
</table>

*All amounts are in milliard 1983 ECU's. A positive effect implies that producers' income, consumers' income, budget costs and EC income were higher when the super-levy system was introduced in 1977.*

6. Consequences for the Netherlands

The model for the Netherlands dairy sector is coupled with the EC model. First, the consequences of the policy alternatives are determined for the EC as a whole. In this way, information relating to prices, production, consumption, exports, budgetary costs, etc. is available for each policy alternative. It is then possible to determine the policy effects for the Netherlands.

The effects of a certain EC policy for the Netherlands are also influenced by special conditions on national level, e.g.:
- the Netherlands' contribution to the EC budget: throughout the whole analysis this share remained at 6.4%;
- the share of the Dutch dairy sector in the production quotas or direct income transfers: in this analysis, production quotas for the super-levy
system of 1984 were based on actual levels. The quotas for a super-levy system introduced in 1977 were based on 1975 production levels. The same holds for direct income transfers;
- the extent to which certain measures are nationally financed: it was assumed that there was no national financing.

The computer model of the Netherlands dairy sector follows the same principles as the EC model. However, the parameter values and data were different (see Table 3 for the supply function and Table 10 for data about the demand side of the model). Information from the EC model was used in the Netherlands model.

Table 10. Information used for the demand side of the Netherlands dairy model: domestic consumption figures

<table>
<thead>
<tr>
<th>Product</th>
<th>Reference Quantity 1983 (1000 tons)</th>
<th>Price Elasticity of Demand</th>
<th>Trend in Per Capita Consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk and milk products</td>
<td>1942</td>
<td>-0.15</td>
<td>-0.5</td>
</tr>
<tr>
<td>Cream</td>
<td>40</td>
<td>-0.34</td>
<td>3.0</td>
</tr>
<tr>
<td>Cheese</td>
<td>179</td>
<td>-0.32</td>
<td>2.0</td>
</tr>
<tr>
<td>Butter</td>
<td>46</td>
<td>-1.50</td>
<td>1.0</td>
</tr>
<tr>
<td>Condensed milk</td>
<td>140</td>
<td>-0.20</td>
<td>-2.0</td>
</tr>
<tr>
<td>Unskimmed milk powder (b)</td>
<td>60</td>
<td>-0.20</td>
<td>0.0</td>
</tr>
<tr>
<td>Skimmed milk powder</td>
<td>12</td>
<td>-0.20</td>
<td>0.0</td>
</tr>
<tr>
<td>Casein</td>
<td>5</td>
<td>-0.20</td>
<td>-0.5</td>
</tr>
</tbody>
</table>

\(a\) Annual increase of population: 0.4%
\(b\) Includes some special products

The results for the policy alternatives, as described in Section 2, for the period 1984-1988 are summarized in Table 11. Here, the effects on producers' income, consumers' income, national budget and national income are all relative to the benchmark policy alternative. The employment effects of the dairy production column were also incorporated in the analysis. In addition, these include the dairy industry (and supplying industries) above the stage of butter and skimmed milk powder, and the export of dairy products. The effects of the three policy alternatives on national income were found to be negative. Of these alternatives, the super-levy system gave best results.

Because the size and the potential production growth of the Netherlands dairy sector is larger than the average for the EC countries, a price decrease and a super-levy system give relatively large negative effects on producers' income and national income. For the dairy producers in the Netherlands, the super-levy system gives the highest producers' income (with the exception of the bench-
mark policy alternative). However, it is clear that the benefits of a policy change for the Netherlands should come from a reform of the CAP for other products.

The repercussions of introducing a super-levy system in 1977 instead of in 1984 are shown in Table 12. This table is similar to Table 9. The share of the Netherlands in EC milk production was 11.4% in 1975 and 11.8% in 1981. This implies that a super-levy system started in 1977 would have resulted in Dutch dairy farmers having a slightly lower share in total milk production. On the other hand, an earlier change of policy would have prevented large investments and resource use in the Netherlands dairy sector, and the budget costs of the dairy market would have been lower.

A policy change in 1977 could have led to a higher national income in the Netherlands. Because actual development over the period 1977-1983 led to an important real price decrease for milk, producers in the Netherlands would have been better off if a super-levy system had been introduced in 1977. Therefore it

Table 11. Aggregated effects on producers' income, consumers' income, budget costs, national income and employment of the dairy production column of the Netherlands for the period 1984-1988: (all amounts are in milliard 1983 ECU's and vis-a-vis the benchmark policy alternative)

<table>
<thead>
<tr>
<th>Policy alternative</th>
<th>Producers' Income</th>
<th>Consumers' Income</th>
<th>Budget Costs</th>
<th>National Income</th>
<th>Employment (in 1000 labour years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benchmark policy alternative</td>
<td>-</td>
<td>-</td>
<td>2.24(^a)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Super-levy system</td>
<td>-1.14</td>
<td>-0.18</td>
<td>-0.85</td>
<td>-0.50</td>
<td>-7</td>
</tr>
<tr>
<td>Price decrease and co-responsibility levy</td>
<td>-1.75</td>
<td>0.23</td>
<td>-0.83</td>
<td>-0.60</td>
<td>-13</td>
</tr>
<tr>
<td>Price decrease and income allowances</td>
<td>-2.60</td>
<td>1.05</td>
<td>-0.85</td>
<td>-0.70</td>
<td>-16</td>
</tr>
</tbody>
</table>

\(^a\) Total budget costs

Table 12. Effects for the Netherlands of introducing a super-levy system in 1977\(^a\) compared with introducing it in 1984

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Producers' income</td>
<td>0.28</td>
<td>0.40</td>
<td>0.68</td>
</tr>
<tr>
<td>Consumers' income</td>
<td>-0.59</td>
<td>-0.30</td>
<td>-0.89</td>
</tr>
<tr>
<td>Budget costs</td>
<td>-1.02</td>
<td>-0.31</td>
<td>-1.33</td>
</tr>
<tr>
<td>National Income</td>
<td>0.71</td>
<td>0.42</td>
<td>1.13</td>
</tr>
</tbody>
</table>

\(^a\) See Table 9.
is only conceivable that farmers' and producers' organizations first tried to delay a change of policy because they:
- expected higher prices;
- feared intensive government intervention in the dairy sector.
This delay was to the detriment of the taxpayer.

NOTES
1. Areas have been calculated by integration of the function in equation (1) with relevant prices and shift factors.
2. A price increase will give the opposite effect: \( Q_1 \) and \( P_1 \) are larger than \( q_1 \) and \( p_1 \), respectively.
3. A change of producers' income can adjust the income of the dairy farmers, dairy industry, supplying industries and supplying farms (feed, green fodder). For the dairy industry and the supplying industries one may expect that cost differences will be passed on mainly to the dairy farmers. Above that, dairy farmers' income is the main part of producers' income.
4. This number has been based on a calculation of 'family farm income' (e.g. income for labour, land and capital owned by the family and used for farming) in relation to the gross revenue of milk. The calculations used average results over the period 1978/79-1979/80 for specialized dairy farms (See Table A).

Table A. Relation between milk revenue and income of dairy farmers

<table>
<thead>
<tr>
<th>Country</th>
<th>Milk Revenue (ECU)</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>Family Income Share in EC Milk Production</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany</td>
<td>22523</td>
<td>14542</td>
<td>12264</td>
<td>10460</td>
<td>46.4</td>
</tr>
<tr>
<td>France</td>
<td>15173</td>
<td>11743</td>
<td>9167</td>
<td>8035</td>
<td>53.0</td>
</tr>
<tr>
<td>Italy</td>
<td>17788</td>
<td>15570</td>
<td>13233</td>
<td>11190</td>
<td>62.9</td>
</tr>
<tr>
<td>Netherlands</td>
<td>47860</td>
<td>26598</td>
<td>21650</td>
<td>17869</td>
<td>37.3</td>
</tr>
<tr>
<td>Belgium/Luxembourg</td>
<td>23547</td>
<td>18590</td>
<td>16184</td>
<td>11638</td>
<td>62.2</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>42115</td>
<td>17645</td>
<td>11204</td>
<td>4874</td>
<td>11.6</td>
</tr>
<tr>
<td>Ireland</td>
<td>15272</td>
<td>12726</td>
<td>11449</td>
<td>7528</td>
<td>49.3</td>
</tr>
<tr>
<td>Denmark</td>
<td>39400</td>
<td>18922</td>
<td>14666</td>
<td>7262</td>
<td>18.4</td>
</tr>
<tr>
<td>EC</td>
<td>42.3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Data from Farm Account Data Network (RICA) for specialised dairy farms. Average of the years 1978/79 and 1979/80

(1) Net value added
(2) (1) minus paid wages and paid rent
(3) (2) minus paid interest. Here the following assumptions were used:
- interest percentage = \( 4 + \frac{1}{2} (IP - 4) \); where \( IP \) = inflation percentage
- share of own capital:
  - 80%: GER, FRA, ITAL, NET, B/L, IRL
  - 70%: UK
  - 60%: DEN

Now 42.3% at farm level implies about \( 42.3 \times \frac{0.88}{1} = 37.2\% \) at the level of the dairy factory. So 40% is somewhat higher.
5. The ex-post calculation cannot be interpreted as proof that the model is perfect, because the values assigned to some parameters were actual.

REFERENCES


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Macro- and micro-effects of the super levy in the Netherlands

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Summary

This article deals with the consequences of a decline in milk production for the Dutch economy. On the basis of theoretical investigations and of the first information from practice an opinion is given on the way dairy farmers in the Netherlands will react to the super levy. On the basis of reactions in the dairy sector and in connected industries the short-term effects on income and employment are calculated with help of input-output-analysis. Also a short sketch is given of the effects in the longer term.

1. Micro-effects of the super levy

1.1. Introduction

It is expected that, in the Netherlands, the introduction of the EC milk quota system will have more impact on farm management and farm income than any previous EC measure. Previous measures only affected the milk price very slightly, so the expansion of the cow herd and the increase in milk yield per cow could be continued. There was no difference between the marginal milk price and the average producer price of milk.

However, in case of the milk quota system, the price of surplus milk is only 25% of the normal producer price. There is no doubt that it is not profitable to produce this surplus milk at such a low price. Also it is expected that the reaction of dairy farmers to this milk quota system will be quite different from former reactions to EC measures.

It is very important to know how farmers will react to the milk quota system, because these reactions will not only have an effect on milk production, but also...
on the production of other agricultural products, on employment in and out of agriculture, on the dairy industry, the feed industry etc.

Though it is not yet quite clear what will be the overall reaction of dairy farmers, an attempt has been made to estimate the possible effects on the basis of current information on actual responses to the super levy, and by using some existing models.

1.2. Reduction of milk production

In the current period, 1984/85, a dairy farmer who is exempt from an additional quota (because of recent investments; because he has suffered a disaster; because he is a 'young' farmer; or because he operates a small holding) has a quota of -8.65% in relation to his milk sales for 1983. The average percentage for all farmers is -6.6%.

EC regulations permit each member state to choose between either an on-farm-quota or a dairy quota. The Netherlands opted for an on-farm-quota. Consequently a dairy farmer has to pay a super levy amounting to 75% of the milk price on milk sales in excess of his quota. Calculations prove that it is not profitable to produce surplus milk. The consequence is that a dairy farmer will try to reduce his milk production to the quota for which he gets the full producer price.

From the realized deliveries of milk in 1984/85 it can be concluded that most dairy farmers reacted as expected. The milk deliveries diminished by 5.6%, which is only 1% less than the obligatory percentage of 6.6%.

1.3. How to reduce milk production

The reduction of milk production per farm can be realized either by a reduction in the number of dairy cows or by a reduction of the milk yield per cow.

Even under a quota system, it remains profitable to have cows with high yields. So long as the milk production potential of the cows has not been utilized fully it is attractive to improve milk yields per cow. If the farmer succeeds in increasing the milk yield per cow by better management it is necessary to diminish — additional to the quota — the number of cows by the same percentage as the milk yield per cow increases. Of course, this improvement in milk yields is less profitable under a quota system because the total milk production of the farm cannot be expanded. Nevertheless the trend to improve milk yields continues.

Only when the amount of concentrates fed in summer is too high in relation to the milk yield, will a small reduction in the milk yield be achieved. But this reduction is more a result of improved feeding efficiency than a strategy to lower milk yields per cow.

Also with respect to this point, the dairy farmers reacted as expected. In the summer of 1984 the consumption of concentrates diminished by 10-20% to a
more normal level of 2 or 3 kg per cow per day. The reduction of the milk yield per cow during the grazing period was 2%. It is expected that the milk yield per cow in the winter period will be about the same as in the winter before, so that the average milk yield per cow per year will be only 1% lower than in the year before.

For the greater part, the reduction of milk production has been realized by a reduction in the number of dairy cows and only for a small part by a reduction in the milk yield per cow.

1.4. Effect of the quota system on farm income

Of course, the quota system affects the farm income. The loss influences factors such as stocking rate, milk yield per cow and the suitability of the superfluous grassland for arable crops.

Results of models show that the loss increases when the stocking rate is lower and the milk production per cow is higher.

Table 1. Decrease of the margin per farm as a consequence of the reduction of the cow herd by 10% on a farm with 60 cows and a level of 400 kg N per ha

<table>
<thead>
<tr>
<th>Milk Production per Cow (kg)</th>
<th>Grassland Stocking Rate at Starting Situation (ha)</th>
<th>Stocking Rate after Reduction (cows/ha)</th>
<th>Decrease of the Margin per Farm (Dfl)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5,500</td>
<td>31.3</td>
<td>1.92</td>
<td>11,049 (7.7%)</td>
</tr>
<tr>
<td></td>
<td>26.6</td>
<td>2.26</td>
<td>8,773 (6.5%)</td>
</tr>
<tr>
<td></td>
<td>20.1</td>
<td>2.98</td>
<td>7,782 (6.4%)</td>
</tr>
<tr>
<td>6,500</td>
<td>32.7</td>
<td>1.83</td>
<td>14,337 (8.2%)</td>
</tr>
<tr>
<td></td>
<td>27.1</td>
<td>2.17</td>
<td>11,390 (6.9%)</td>
</tr>
<tr>
<td></td>
<td>21.5</td>
<td>2.80</td>
<td>10,154 (6.9%)</td>
</tr>
</tbody>
</table>

a Calculations of a working group; Publication No. 29 of the Research and Advisory Institute for Cattle Husbandry, 1984.

The fall in income on the farms with higher stocking rates is smaller because of their saving in high marginal feed costs. If the stocking rate is so moderate that after reducing the number of cows, the amount of home-produced winter-feed is more than 9 kg DM (dry matter) per cow per day, it depends on the soil whether or not the level of 400 kg N per ha will be maintained. If the soil is suitable for arable crops it may be profitable to maintain the level of 400 kg N per ha on the area of grassland needed for the reduced herd and to plough up the superfluous grassland for arable crops (Table 2). This is the case on many
Table 2. Required minimum margin per ha land that is no longer required for dairy cattle, to keep the loss by the super levy at the same level\textsuperscript{a,c}

<table>
<thead>
<tr>
<th>Milk Production</th>
<th>Stocking Rate at Starting Situation</th>
<th>Super levy 10% Required Minimum Margin\textsuperscript{b}</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(cows per ha)</td>
<td></td>
</tr>
<tr>
<td>5,500</td>
<td>1.92</td>
<td>1,554</td>
</tr>
<tr>
<td></td>
<td>2.26</td>
<td>2,294</td>
</tr>
<tr>
<td></td>
<td>2.98</td>
<td>2,662</td>
</tr>
<tr>
<td>6,500</td>
<td>1.83</td>
<td>1,460</td>
</tr>
<tr>
<td></td>
<td>2.17</td>
<td>2,374</td>
</tr>
<tr>
<td></td>
<td>2.80</td>
<td>2,828</td>
</tr>
</tbody>
</table>

\textsuperscript{a} If an arable crop has a margin of revenues less variable costs which is higher than the balance, it is profitable to grow arable crops on the remaining area.

\textsuperscript{b} Margin per ha of arable crops (Dfl.); cereals 1000–1600, rapeseed 1200–1500, industrial potatoes 2200, peas 1500–1900, sugarbeet 3000.

\textsuperscript{c} Calculations of a working group; Publication No. 29 of the Research and Advisory Institute for Cattle Husbandry, 1984.

Farms in the EC, because most dairy farms were mixed farms in the past. In this case there is a risk that the surplus problem will move from dairy farms to arable farms.

Only on farms with a low stocking rate on grassland which is not suitable for arable land (peat soil) will it be necessary to decrease the level of 400 kg N per ha of grassland. That is the only way to save on costs. On a number of such farms it is to be expected that alternative uses for grassland, like sheep, suckling cows or beef production will be introduced or expanded, but not on a large scale.

Though a negative effect of the quota system on farm income is to be expected, the income level on Dutch dairy farms will not change very much in the bookkeeping year 1984/85 compared with the previous year 1983/84. This is because the fall in the price of concentrates by 15% and the lower consumption of concentrates compensate for the greater part the fall in the income due to the reduced cow herd. Moreover, the labour income of the farmer was very moderate in the year 1983/84. Of course compared with a good year, the labour income of the dairy farmer would have decreased as a consequence of the quota system.

1.5. Management on dairy farms in the coming years

With the introduction of the quota system the strong expansion of dairy farms in the Netherlands came to an end. Now the question is which possibilities are available for dairy farms to improve their income situation. Apart from purchase
of land with quota for milk production it has become very difficult to improve labour productivity on family farms, which, in the Netherlands, amount to more than 80% of the total number of dairy farms.

The only possibilities for increasing income can be found in the areas of improving the efficiency of milk production, feeding, grassland exploitation, silage-making and veterinary herd health. 'Not more, but better' is the slogan for the management of dairy farms in the coming years.

A recent comparison between farms with a high yield per cow (6300 kg) and a lower yield per cow (5400 kg) showed a difference in cost price per kg of milk of about Dfl. 0.09. This difference in milk yield per cow accounted for 46% of the total financial differences between the farms (Table 3).

These high milk yields are connected with higher managerial skills on the part of the farmer, which results in better grassland management, fodder harvesting, feeding efficiency, breeding, fertility of the cows, etc.

Table 3. Returns and costs per 100 kg milk (Dfl) in 1978/79 up to 1980/81 as affected by milk production per cow

<table>
<thead>
<tr>
<th>Item</th>
<th>Group I (5,410 kg milk per cow)</th>
<th>Group II (6,310 kg milk per cow)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total gross returns</td>
<td>76.47</td>
<td>75.90</td>
</tr>
<tr>
<td>Costs:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>purchased concentrates and roughage</td>
<td>25.00</td>
<td>22.51</td>
</tr>
<tr>
<td>fertilisers and land rent</td>
<td>7.73</td>
<td>6.33</td>
</tr>
<tr>
<td>labour</td>
<td>18.25</td>
<td>15.87</td>
</tr>
<tr>
<td>contract work</td>
<td>1.72</td>
<td>1.60</td>
</tr>
<tr>
<td>machinery and equipment</td>
<td>9.85</td>
<td>8.30</td>
</tr>
<tr>
<td>buildings</td>
<td>7.49</td>
<td>6.41</td>
</tr>
<tr>
<td>other costs</td>
<td>11.15</td>
<td>10.77</td>
</tr>
<tr>
<td>Total gross costs</td>
<td>81.19</td>
<td>71.79</td>
</tr>
<tr>
<td>Milk price</td>
<td>63.06</td>
<td>63.55</td>
</tr>
<tr>
<td>Net cost price</td>
<td>67.78</td>
<td>59.44</td>
</tr>
<tr>
<td>Margin</td>
<td>-4.72</td>
<td>4.11</td>
</tr>
</tbody>
</table>


A high milk yield can only be realized with optimal grassland exploitation and silage-making. The intake of forage dry matter by the cows depends largely on its nutritional value and digestibility. Therefore, the contribution made by forage to animal production depends to a large extent on the quality of the fodder. High quality silage is particularly valuable for high performance animals.
A cow given high quality silage will consume more of that silage than a lower quality product.

A higher intake together with a higher nutritional value results in a much higher milk production potential from forage and less dependence on supplementary feeding stuffs.

Optimal grassland exploitation demands an optimum rate of nitrogen. In the Netherlands this optimum rate is about 400 kg N per ha on sandy, clay and wet peat soils and 250 kg N on peat soils with normal moisture retention.

The question whether the introduction of the milk quota system will affect the optimum rate of nitrogen depends on the stocking rate and on the suitability of the soil for arable crops, as already discussed above.

2. Macro-effects of the super levy

2.1. Introduction

The decrease in milk production because of the implementation of the super levy has consequences not only for the dairy sector, but also for the sectors which are directly or indirectly connected with the dairy sector by delivery of means of production or by processing dairy products. For this reason an investigation has been made by the Dutch Agricultural Economics Research Institute (LEI) of the effects of the decrease in milk production on the national economy. This part of the article is a summary of the project as far as it concerns income and employment. Effects on the formation of prices are not taken into consideration. In the project, and also in this article, a distinction is made between effects on a short term (1½ to 2 years), where there is a distortion of the historical development, and on a longer term, where there is a development in the direction of a new ‘equilibrium’. The short-term effects on investments are discussed separately.

2.2. Short-term effects due to decreased production

2.2.1. Method and starting points

In approaching the short-term consequences of the decrease in milk production, use is made of a so-called agricultural input-output table in which Dutch agriculture is divided into 15, and the Dutch food industry into 10 branches of activity. These tables are composed by the LEI every five years within the framework of the general input-output table of the Central Bureau of Statistics (CBS). As the most recent agricultural table was that for 1975, the most relevant parts are extrapolated to 1984. In this input-output table, depreciation and consumption form a part of the primary costs. For this reason, the influence of smaller replacement investments and of changes in consumption on income and employment have to be calculated separately.
In principle, it is possible to calculate on a basis of these extrapolated agricultural input-output-tables, supplemented with figures on employment, and the consequences of the decrease in milk production for income and employment in the dairy sector and in other sectors. In practice, however, the technical coefficients are not static as in the model and (connected) income and (connected) employment will not decrease proportionally to the milk production. Related to this, a number of effect-coefficients are employed. It is assumed that:

- the number of labour units in the dairy sector hardly decreases — i.e. that the coefficient is 0.1, or, in other words, that a 1% decrease in milk production reduces the number of labour units by 0.1%;
- every cow that is disposed of has a 15% lower milk production than the average;
- a 1% lower milk production means a decrease of 1.6% in the purchase of feedstuffs and of 0.4% of the purchase of other means of production;
- less milk implies less production of butter and skimmed milk powder, of which the production is rather labour-extensive, and so, because of that, a 1% decrease in milk deliveries has an employment effect of only 0.25% on the dairy-factories and, together with losses caused by not operating at full capacity, an effect on value added of 0.4%;
- with a 1% decrease in milk production, employment in the cattle feedstuffs industry diminishes by 1.6%, and the connected value-added declines by 1.8% to cover losses for not operating at full capacity;
- on balance, after an initial increase, the production of beef decreases by 0.5% with a 1% decrease in milk production;
- every percent decrease of milk production induces a decline of employment and income in veal production and in the production of milk for calves, because fewer calves are available for fattening;
- for all connected activities not mentioned so far, such as deliveries to the feed industry and of non-agricultural means of production to the dairy industry, a decrease can be expected of 1% for services and of 0.5% for other deliveries for each percent reduction in milk production.

2.2.2. Estimated results

Based on the actualised agricultural input-output table and the before-mentioned suppositions, it is estimated that current milk production in the Netherlands must decrease by 7.6% in the period 1985/86. The results are summarized in Table 4.

The figures must be seen against the background that in the Netherlands about 3% of national income and employment is connected with the production and processing of milk (excluding investments, see later). The mentioned reduction of milk-production results on a short term in a drop of 5% in the income connected with milk-production. About 45% of this decline is borne by the primary sector and a quarter by the food industry. The loss of jobs comes to 2.5% or 3200, of which only 20% are in the primary sector, more than 30% in
Table 4. *Estimated term consequences of a decrease in milk production for added-value and employment (excluding effects through expenditures and investments)*

<table>
<thead>
<tr>
<th>Branch of industry:</th>
<th>Estimated Starting Situation in 1984</th>
<th>Reduction by a Decrease of 7.6% in Milk Production</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(mill. Dfl.) (in man-years)</td>
<td>(mill. Dfl.) (%) (man-years) (%)</td>
</tr>
<tr>
<td>A. Agriculture</td>
<td></td>
<td></td>
</tr>
<tr>
<td>of which:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- dairy sector</td>
<td>3,651 70,100</td>
<td>226 5.7 724 1.0</td>
</tr>
<tr>
<td>- fattening of calves</td>
<td>151 1,300</td>
<td>17 11.0 143 11.0</td>
</tr>
<tr>
<td>- other agricultural sectors</td>
<td>205 1,800</td>
<td>15 7.3 48 2.7</td>
</tr>
<tr>
<td>of which:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- dairy sector</td>
<td>1,459 19,900</td>
<td>45 3.1 379 1.9</td>
</tr>
<tr>
<td>- feed industry</td>
<td>297 3,700</td>
<td>37 12.5 443 12.0</td>
</tr>
<tr>
<td>- slaughterhouses and meat industry</td>
<td>251 4,100</td>
<td>20 8.0 300 7.3</td>
</tr>
<tr>
<td>- other food and beverages</td>
<td>130 1,300</td>
<td>7 5.4 75 5.8</td>
</tr>
<tr>
<td>Total agri-business (A + B)</td>
<td>6,193 102,200</td>
<td>340 5.5 1,922 1.9</td>
</tr>
<tr>
<td>B. Food and beverages</td>
<td></td>
<td></td>
</tr>
<tr>
<td>of which:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- dairy industry</td>
<td>1,137 29,000</td>
<td>111 5.2 1,197 4.1</td>
</tr>
<tr>
<td>- feed industry</td>
<td>297 3,700</td>
<td>37 12.5 443 12.0</td>
</tr>
<tr>
<td>- slaughterhouses and meat industry</td>
<td>251 4,100</td>
<td>20 8.0 300 7.3</td>
</tr>
<tr>
<td>- other food and beverages</td>
<td>130 1,300</td>
<td>7 5.4 75 5.8</td>
</tr>
<tr>
<td>Total agri-business (A + B)</td>
<td>2,872 29,500</td>
<td>142 4.9 1,284 4.4</td>
</tr>
<tr>
<td>C. Other industries</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total industries (A + B + C)</td>
<td>9,006 131,700</td>
<td>470 5.2 3,206 2.4</td>
</tr>
</tbody>
</table>
the food industry, and not less than about 40% in other sectors. So, relatively speaking, the drop in cumulated income is about 2/3 and cumulated loss of jobs about 1/3 of the decline in milk production. However, these figures still have to be raised by the effects of a decline in spending as a result of the drop in income. For the agricultural population, it is supposed that the deterioration of income does not affect spending but induces smaller savings. For the other sectors it is supposed that the spending up to the level of the legal minimum wage is set exogenously. The loss of employment due to reduced spending may then be estimated at 500 to 550 jobs.

2.3. Short-term consequences in relation to smaller investments

The decline in milk production not only affects production in supplying and processing industries but also the volume of investments, and, because of that, income and employment. These effects are only examined for the dairy sector and the dairy industry, but there will also be an effect on the level of investments in other branches. In connection with the great margins of uncertainty that have to be dealt with, minimum and maximum alternatives are set up.

For the dairy sector, the reference level has first to be determined. This level is considerably smaller than that of the last 10 years as the Dutch dairy sector was modernising itself at a high rate. For example, two-thirds of the dairy cows are housed now in new cowhouses with cubicles.

In a minimum alternative a distinction is made between development investments and replacement investments. A large part of the investment on dairy farms consists of investments in cowhouses and dead inventory for cowhouses. The part of these investments used for development is set at a third with respect to the increase in the number of cows on farms which received a interest-subsidy of the EC inter alia in relation to the building of new cowhouses. Further it is assumed that these development investments will diminish by 75%, but total halt is not envisaged because, as the number of farms decrease, development investments on other farms remain possible. As a consequence, total investments decline by 15%.

In a maximum alternative it can be assumed that, in practice, development and replacement investment often go together: when there is no possibility for expansion, then the attractiveness of replacement diminishes. In this situation, it can be assumed that the investment in buildings will decline by 40%, and other investments by 30%. The actual figures for the second and third quarter of 1984 show that applications for building permits decreased even more - by about 60%.

On basis of information from the Dairy Board, the net-investments for the dairy industry are assessed on 30% of the gross investments. By labour- and energy-saving investments and by environmental instruments, net-investments will not fall off completely. For this reason, in a maximum alternative, a reduction of 20% of gross investment is assumed. This implies that investments decline
not only for the production of butter and skimmed milk powder, but also for the production of evaporated milk, cheese etc.

In the minimum-alternative, we do not anticipate a proportional decline of investments, but rather a halt in the net-investments for butter and skimmed milk production (the surplus-products) and a limitation in general investments such as in means of transport. On this basis a decrease of 10% is assumed for this alternative.

The drop in investments which is calculated on the basis of the previously mentioned assumptions, is to be found in Table 5 (columns 1-4), and the effect of this decline is assessed on added-value and employment in construction and installation firms. It is assumed that the cumulated added-value in construction and installation firms amounts to 63% and the added-value per worker to Dfl. 61,000.–. The results are mentioned in the two last columns of Table 5.

The great difference in results reflects the uncertainty in the estimation of the effects of the decline in milk production on the volume of investments. Yet it is clear that the loss of income and employment in construction and installation firms is considerable. Income and employment in construction and installation firms as far as they are connected with the investments in these sectors amount to nearly 900 million guilders and nearly 15000 jobs, respectively. As the last figure is equivalent to between 4 and 4.5% of employment in these branches of industry, the influence for these sectors as a whole remains restricted to about 1%.

Also, in comparison with the effects mentioned in Table 4 the consequences of smaller investments for income and employment are considerable. The reader is reminded of the fact that the effects for other branches of industries as, for example, the feed industry are not taken into account, neither are the effects of decreased deliveries to construction and installation firms. Finally, no attention is paid to effects on spending which can occur especially when the effects on employment result in more unemployment.

2.4. Consequences on a longer term

On a longer term, there are more possibilities for adjustments than on a short term: after 2 years, the effects will be smaller than in the first years. How these adjustments will develop is uncertain, however, and depend among other things on the way in which the super levy is put into practice.

As to the dairy sector, a further increase in milk production per ha based on a larger use of concentrated feeding stuffs is possible and consequently a further decline in number of dairy cows can be expected, as well as a development in the direction of dual-purpose cows which are suited for both milk and meat production. In the first mentioned development, the consequences for the feed industry will be smaller than in the last mentioned one.

Especially in a development towards cows with a higher milk-yield, land will become available, which will be utilized for other agricultural production. This
Table 5.  Estimated reduction in added-value and employment in construction and installation industries as a consequence of a decrease in investments in the dairy sector and in the dairy industry.

<table>
<thead>
<tr>
<th>Assumed decrease in investments (%)</th>
<th>Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>dairy sector</td>
</tr>
<tr>
<td>I</td>
<td>(540)</td>
</tr>
<tr>
<td>II</td>
<td>40</td>
</tr>
<tr>
<td>III</td>
<td>15</td>
</tr>
<tr>
<td>IV</td>
<td>40</td>
</tr>
</tbody>
</table>
land could be used for the production of mutton and beef. These are likely developments when viewed in relation to the available know-how and experience of the dairy farmers and the space that becomes available in cowhouses. When the land is suitable, some expansion of arable farming and horticulture is also possible (see Section 2 of this article).

A result of these probable developments will be that fewer calves will be available for fattening. This can partly be compensated for by decreasing the export of calves from the dairy sector. Nevertheless, the fattening sector and the activities connected with this sector will probably decline in volume to some extent.

The labour that is released by the super levy probably cannot be fully employed in the 'new' land-bound activities. So there will be also a tendency towards expansion in pig-farming and poultry. The possibilities in these sectors are limited, however, as there are surpluses of manure and policy measures, partly in preparation, to put a halt to these surpluses. The need for jobs outside agriculture will increase.

The negative consequences of the super levy for income and employment in agriculture, the feed industry, the fertilizer industry, the slaughterhouses etc. and in construction will probably be smaller in the long run than in the near future. An exception is the dairy industry, where the limitation of milk production, also in the long run, will be translated into a greater decline of employment.

2.5. Concluding Remark

This part of the article described the macro-economic effects of a decrease in milk production of 7.6%. One has to realize that, in the Netherlands, milk production increased by 3.4% on average per year. In comparison with this growing production, the consequences of the super levy are bigger than have been described. On the other hand, a limitation of the continually increasing production of milk was inevitable and other policies to achieve that end would have had approximately the same consequences as the super levy.

NOTES

2. The larger the input-output-table the larger the multipliers obtained of the turnover, however, the extent of the table does not influence the multiplier of income and employment.
The implementation of the EC milk quota*

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Summary

When analysing the process of government policy formation two elements can be identified: the choice of policy instruments (policy-setting) and the setting of the levels of these instruments (policy implementation). This paper presents a model which attempts to explain the recent implementation of the EC milk quota, while taking the timing of the change in policy instrument and the qualitative choice of the new instrument as exogenous. A preference function for the Council of Ministers is presented, which has been estimated using historical milk sector intervention prices. By maximizing this preference function subject to the constraints imposed by a milk sector sub-model, it is possible to derive a forecast of the level of milk quota. This exercise has been undertaken for two years; 1980/81, where the results are compared with those generated by the model when a quota mechanism is not used, and for 1984/85, when the results are compared with the actual decision taken by the Council of Ministers. Possible developments in the specification of the preference function are discussed in the light of these results.

1. Introduction

When describing the behaviour of governments, two elements can be identified. One is the qualitative nature of the policy, which consists of the institutional

* The econometric work presented in this paper was undertaken as part of a research project funded by the Ministry of Agriculture, Fisheries and Food. The author acknowledges the helpful comments made on a draft of this paper given by D. Colman and T. Young of Manchester, and two anonymous reviewers, and also the assistance given by P. de Kobbe, who checked (and corrected) the results presented in the paper. However, only the author is responsible for any remaining errors.
framework and policy instruments chosen to achieve its goals; where there may be a wide range of alternatives available. The second element is the level at which the policy instruments are set within the institutional framework. In their extensive review article, Rausser, Lichtenberg and Lattimore (1981) call these two aspects policy-setting and policy implementation. Both of these aspects are presented in the recent introduction of milk quotas in the EC. The institutional framework and policy instruments used within the CAP have undergone a radical change, and a particular value for the new policy instrument has been chosen. This paper attempts to model the implementation of the new policy, and explain the level of the milk quota, while taking the decision to adopt a quota mechanism as exogenous. This approach conforms to that used by the majority of empirical work on agricultural policy, where most attention has been placed on policy implementation rather than on policy setting. The reason for this probably centres around the difficulties of modelling a process which is discrete, happens very infrequently and which would need to take into account the entire set of goals and instruments available to the government.

Even if the analysis is restricted to the policy implementation, there are difficulties. One clearly cannot estimate a policy instrument behavioural equation, which is one approach identified by Rausser, Lichtenberg and Lattimore (1981: 567) as there have been no previous observations on the milk quota level. Instead, one needs to have a knowledge of the governing preference function from which, in conjunction with the constraints imposed by the relevant economic structure, it is possible to derive the level of the quota. In the following section, the method used to ascertain the policy preference function of the Council of Ministers with respect to the milk sector is detailed.

2. The methodology underlying the estimation of the preference function

The original motivation that drove the research involved in identifying the preference function was a desire to extend the work on endogenous price policies undertaken by Sarris and Freebairn (1983). The supply and demand functions for the products under consideration are assumed to be linear

\[
S_t = S(P_{st}, \ldots) \\
D_t = D(P_{dt}, \ldots)
\]

where \( S_t \) and \( D_t \) are the quantities of the good supplied and consumed in year \( t \). \( P_{st} \) and \( P_{dt} \) are the prices paid to producers and paid by consumers respectively, where both are determined by the Council of Ministers. In cases where there is no separate policy for controlling the consumer price it is assumed to be proportional to the producer price, so that a single policy price is used.

It is further assumed that, over the relevant data range, the estimated supply
The implementation of the EC milk quota 463

curve is a close approximation to the marginal costs of the suppliers, and that the estimated demand curve is a close approximation to the compensated demand curve. It is then possible to ascertain the gains or losses to producers and consumers as a result of imposing a policy price, relative to the level of the producer/consumer surplus that occurs under some base policy.1 If the base policy is one of free trade then these are given by:

\[
GP_t = \frac{1}{2} \cdot (P_{st} - P_{wt}) \cdot [S(P_{st}) + S(P_{wt})] \tag{3}
\]

\[
GC_t = \frac{1}{2} \cdot (P_{dt} - P_{wt}) \cdot [D(P_{dt}) + D(P_{wt})] \tag{4}
\]

for producers and consumers respectively, where \(P_{wt}\) is the world price.

In order to maintain the difference between the domestic and world price some government activity is needed. The gain or loss to government revenue as a result of this activity is given by

\[
GG_t = (P_{st} - P_{wt}) \cdot [D(P_{dt}) - S(P_{st})] - (P_{st} - P_{dt}) \cdot D(P_{dt}) \tag{5}
\]

The policy-maker is then assumed to maximize a preference function of the form

\[
E_{t-1}(W_t) = P1 \cdot E_{t-1}(GP_t) + P2 \cdot E_{t-1}(GC_t) + P3 \cdot E_{t-1}(GG_t)
+ \frac{P4}{2} \cdot (P_{dt} - P_{dt-1})^2 + \frac{P5}{2} \cdot (P_{st} - P_{st-1})^2 \tag{6}
\]

Subject to equations (1), (2), (3), (4) and (5) above. The elements \(P1-P5\) are the weights that the policy-maker puts on each argument of the function. \(E_{t-1}\) is the expectations operator, so for example, the term \(E_{t-1}\) is read as the expectation, taken at time \(t-1\), of the value of the preference function at time \(t\). The use of expectations is needed as the supply and demand relationships and the world price will not be known with certainty for the period in which the policy will be operational. The final two terms of the function are stability terms, reflecting the government's desire for prices to be stable over time.

The maximization results in behavioural equations for the policy prices where, if the supply and demand equations are estimated separately, the only unknown parameters are the weights of the preference function.2 These can be identified by estimating the equations as a system using a full information maximum likelihood procedure.

3. The milk-sector model

The milk-sector model that has been estimated broadly follows the outline of the previous section, but with some slight deviations to accommodate the points, and describe the method used to accommodate expectations within the
particular structure of the European milk-sector. The full set of estimated equations is given in the Appendix, but here we will briefly give the salient points, and describe the method used to accommodate expectations within the model.

There are three policy prices in the model, the intervention prices of butter and skimmed-milk powder (SMP) and the subsidised price of SMP used for animal feed. There are also two categories of producer identified, milk producers and those who are feeding animals with SMP.

3.1. Supply and demand specification

The supply of milk is assumed to respond to the target price of milk, which in turn is defined as a weighted average of the butter and SMP prices where the weights are the technical yield coefficients for the product from raw milk. Because of the difficulties caused by the number of milk products that are consumed, two composite demand series are constructed, fats and solids non-fats, which consist of the quantities consumed by humans of these two elements in all milk products. The per capita consumption of these products is related to the intervention prices of butter and SMP. A further demand for solids-non-fats is the subsidised sales of SMP for animal feed, which is determined by the subsidised price of SMP. The producer surplus of animal producers is defined as the area below the demand curve for SMP fed to animals, and above the subsidised price (Just, Hueth and Schmitz, 1982: 58-64). There could be some degree of overlap between the group identified as ‘milk producers’ and those who are ‘animal producers’. However, the two groups have been included separately in the preference function rather than create a single ‘livestock products’ group.

Government expenditure is determined by the degree of self-sufficiency in butter and SMP, which is calculated from the estimated demand for those products and their supply. The supply is implied by the supply of raw milk and the technical yield coefficients of the product from raw milk.

3.2. Expectations

Although the estimated demand and supply equations use real prices [nominal deflated by the community Retail Price Index (RPI)] the Council of Ministers can only determine nominal prices conditional upon an expected RPI. The assumption made is that a naive expectation is made of the rate of change of the index. In a similar manner, naive expectations are taken about the level of the real world price of butter and SMP, and the offer price of soya cake. The human population and the yield of milk are expected to follow constant percentage growth trends. Only the intervention price of wheat takes its actual value, as a hierarchical structure is hypothesised, with the price-fixing in the milk sector following that which occurs in the cereals sector.
3.3. Estimation

The three equations that are generated from the maximization of the preference function have been estimated simultaneously, imposing the cross equation restrictions, and the estimated parameters are reported in the Appendix. Because the estimated behavioural equations are homogeneous of degree zero in the parameters of the preference function, a further restriction has to be imposed if the parameters are to be identified. To this end the weight attached to the government expenditure term has been constrained to equal unity. The parameters of the welfare function are all well-defined apart from the butter price stability parameter; although one should be cautious in the use of the t-statistic in a non-linear system (Wymer, 1974: 5). As would be expected, the weight given to producers is greater than that given to other groups, although the low weight on 'animal producers' seems to indicate a clear distinction between these and 'milk producers' in the minds of the Ministers: even if this is not so in practice.

4. Producer surplus: Definition under quotas

Having derived an estimate of the welfare function, we can now use it to derive the optimum quota. However, with a quota imposed, equation (3) above no longer represents the change in producer surplus. Instead we must consider Figure 1.

![Figure 1. Producer surplus under a quota](image)

SM is the supply curve for milk. It is estimated over a fairly small range of prices so that the extrapolation back to $Q_1$ is not considered to have any 'real' economic interpretation. Previously we have considered the arguments of the
expressions for the optimum prices, and furthermore, the actual levels of the surplus could be used. Therefore, it is possible to define producer surplus in the following manner without causing any distortions:

\[ PS = TPM \cdot Q_2 - \frac{1}{2} \cdot (Q_2 - Q_1) \cdot P_1 \] 

where

- \( TPM \) = price of milk received by farmers
- \( Q_2 \) = the quota level
- \( P_1 \) = price needed to achieve the quota if there were no quantity restrictions
- \( Q_1 \) = hypothetical output at zero price.

Thus, the producer surplus is a non-linear function of the quota level and the intervention price of butter and SMP. The only other effect of the quota is that the milk supply terms in the government expenditure term are replaced by the quota level.

5. Optimum policy implementation 1980/1

The estimated preference function has been used to simulate the optimum policy implementation under the two policy sets; with and without the possibility of a quota limitation on the supply of milk. This exercise is useful in that it allows a comparison of the policy implementation under the different policy mechanisms, but using a common data base and expectations.

The first point to note is that the quota level is binding, and represents a 5.4% cut in the level of output compared with the output expected under the unconstrained policy, and a 2% reduction on the previous years output.

The formula used to calculate the subsidized price of SMP is unchanged by the introduction of the quota, and thus is a constant between the two scenarios. The relationship which determines the level of the subsidized price is the marginal cost to the government balanced against the marginal gain to livestock producers, and as long as the introduction of the quota does not impose a quantity constraint on the purchase of SMP it does not affect that relationship.

The introduction of the quota does affect the intervention prices of butter and SMP with the constraint upon production enabling a higher price to be set. The reason for this is clear. Without a quota, the impact of an increase in the intervention prices on government expenditure is two-fold: from the widening of the gap between domestic and world prices, and from the increase in the supply of milk that the increase in price calls forth. The latter quantity effect is ruled out by the introduction of the quota.

The financial implications are quite profound, with a 21% cut in the cost of supporting the price. It would be interesting to evaluate the impact of the quota on farmers as implied by the differences in producer surplus between the two policies. The percentage change in producer surplus would be the easiest way to
Table 1. **Optimum Policy Implementation 1980/81**

<table>
<thead>
<tr>
<th></th>
<th>With Quota</th>
<th>Without Quota</th>
<th>Actual Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td>Welfare function</td>
<td>160635</td>
<td>160370</td>
<td>-</td>
</tr>
<tr>
<td>Quota level (000t)</td>
<td>91582</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Expected milk supply (000t)</td>
<td>-</td>
<td>96829</td>
<td>-</td>
</tr>
<tr>
<td>Intervention price of butter [ECU/t]</td>
<td>3168.5</td>
<td>3168.0</td>
<td>2916</td>
</tr>
<tr>
<td>Intervention price of SMP [ECU/t]</td>
<td>1273.2</td>
<td>1254.6</td>
<td>1215</td>
</tr>
<tr>
<td>Subsidised price of SMP [ECU/t]</td>
<td>616.4</td>
<td>616.4</td>
<td>675</td>
</tr>
<tr>
<td>Expected government expenditure [MECU]</td>
<td>1917</td>
<td>2412</td>
<td>-</td>
</tr>
</tbody>
</table>

interpret the effect. However this cannot be meaningfully calculated as the expression for producer surplus given by equation 7 is an overstatement of the returns to the milk producer. One can only record that the imposition of the quota results in a fall in producer surplus as compared with no quota being used and that this is equivalent to a reduction of 1.3 ECU per cow, which appears to be fairly small.

The fact that producer surplus falls may seem surprising, but it is caused by the constraint on changing the prices implied by the stability parameters. Thus, output is cut back but prices do not rise sufficiently to offset this. In the long-run position, producer surplus is greater with quotas than without.

A final point to note from Table 1 is that the prices generated by the model without quotas are not unacceptable compared with the actual values, and these error margins are representative of those generated throughout the estimation period.

6. **The implementation of the milk quotas 1984/85**

We now turn to a comparison of the Council of Ministers decision on the implementation of the quota, and the forecast generated by the model. The assumption has had to be made that the entry of Greece into the Community has not affected the weights placed on the arguments of the preference function, and that the supply and demand relationships hold when adjusted to simulate for the EC-ten as opposed to the nine for which they were estimated. One also has to assume that the weights hold after the decision has been taken to change to an alternative policy framework.

It is clear from Table 2 that the actual decision is much more restrictive than that which the model forecasts. Although the quota is only 3% greater than that imposed by the Council of Ministers, both of the projected intervention prices are substantially higher. This results in a substantially higher level of expenditure than that generated by the actual decision (2015 M ECU compared with 1260 M ECU). These errors compare unfavourably with those generated by the un-
Table 2. Optimum Policy Implementation 1984/85

<table>
<thead>
<tr>
<th>Welfare function</th>
<th>With Quota</th>
<th>Without Quota</th>
<th>Actual Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quota level [000t]</td>
<td>156776</td>
<td>156697</td>
<td>-</td>
</tr>
<tr>
<td>Expected milk supply [000t]</td>
<td>-</td>
<td>106459</td>
<td>-</td>
</tr>
<tr>
<td>Intervention price of butter [ECU/t]</td>
<td>3786.4</td>
<td>3785.6</td>
<td>3195</td>
</tr>
<tr>
<td>Intervention price of SMP [ECU/t]</td>
<td>1831.8</td>
<td>1806.2</td>
<td>1659</td>
</tr>
<tr>
<td>Subsidised price of SMP [ECU/t]</td>
<td>876.4</td>
<td>876.4</td>
<td>1207</td>
</tr>
<tr>
<td>Expected government expenditure [MECU]</td>
<td>2016</td>
<td>2148</td>
<td>-</td>
</tr>
</tbody>
</table>

constrained model for the 1980/81 year. The source of these errors could lie anywhere in the formulation of the model, or the assumptions used when applying the model to the analysis of the quota implementation. However, the fact that the forecast quota is acceptably close to the actual and that the government expenditure predicted by the model is so large gives us confidence in the basic structure of the model, while indicating areas where further development is needed. Thus, one is led to ask which factors that influenced the Council of Ministers decision have been excluded from the model. The most important element is the overall budget constraint faced by the CAP and its imminent breaching at the time of the 1984/85 policy implementation. Therefore, even if the model were correct in every other detail, it would not capture the substantial cost involved in overrunning the budget. This lack of a budget constraint need not invalidate the results of the original estimation. As Tangermann (1984: 12) has suggested, the Council of Ministers were free to increase policy prices each year without regard to expenditure as long as this did not reach the financial ceiling of the Community budget.

The best method of incorporating the budget effect into the quota model is unclear: the inclusion of an explicit budget constraint into the maximization problem is difficult when a single sector is being considered in isolation. An alternative would be to raise the government expenditure term in the welfare function to a power so that at higher levels of expenditure the marginal ECU spent reduces welfare more than at lower levels. In fact the possibility of making the government expenditure term non-linear has already been explored, but the non-linearity introduces formidable difficulties for estimation and no satisfactory results have yet been achieved.

7. Conclusions

The problems posed in analysing the implementation of a new policy instrument are substantial, as one has no historical record of how policy-makers use that instrument to achieve their goals. In this paper we have attempted this analysis
using a welfare function estimated under price policies, and then solved for the extended policy set of prices and quota. This procedure has generated an acceptable value for the instrument under consideration, the milk quota, and confirms the value of the approach. Furthermore, this rigorous ex-post test of the validity of the welfare function (not only outside the data period used for estimation, but also under a different policy-setting) provides important feedbacks to the specification of the welfare function which can guide future analysis of policy implementation in the EC.

APPENDIX

Estimated supply and demand equations
(t-statistics are given in parentheses)

*Per capita human consumption of solids-non-fats*

\[
HCSNF_t = 18.2 - 0.0333 \frac{IPSMP_t}{RPI_t} + 0.0147 \frac{IPB_t}{RPI_t}
\]

\[
\bar{R}^2 = 0.617
\]

*Per capita human consumption of fats*

\[
HCBUT_t = 14.0 - 0.00276 \frac{IPB_t}{RPI_t}
\]

\[
\bar{R}^2 = 0.371
\]

*Population of the EC*

\[
POP_t = 1.0021 POP_{t-1}
\]

\[
\bar{R}^2 = 1.00
\]

*Consumption of SMP by animals*

\[
ACSMP_t = 1176 + 0.7193 ACSMP_{t-1} - 180.07 \frac{SPSMP_t}{OPSC_t}
\]

\[
\bar{R}^2 = 0.756
\]

*Dairy herd of the EC*

\[
COW_t = 9.089 + 0.4769 COW_{t-1} + 2.119 \frac{TPM_t}{IPW_t}
\]

\[
\bar{R}^2 = 0.6184
\]
Milk yield per cow

\[ YM_t = 1.0218 \times YM_{t-1} \]

\[ R^2 = 0.9929 \]

Council of Ministers preference function

\[ W_t = 1.888 \times GP_t + 1.507 \times GC_t + 1.046 \times GAF + GG \]

(12.6) \hspace{1cm} (7.2) \hspace{1cm} (20.3)

\[- 18.629 \frac{IPSMP_t}{RPI_t} - \frac{IPSMP_{t-1}}{RPI_{t-1}} \]

(4.1) \hspace{1cm} \frac{IPB_t}{RPI_t} - \frac{IPB_{t-1}}{RPI_{t-1}} \]

\[- 4.769 \frac{SPSMP_t}{RPI_t} - \frac{SPSMP_{t-1}}{RPI_{t-1}} \]

(3.3)

List of exogenous variables and terms within the preference function

The definition of the endogenous variable appears before each equation.

\[ IPSMP \] : Intervention price of skimmed-milk powder (ECU/tonne)

\[ IPB \] : Intervention price of Butter (ECU/tonne)

\[ RPI \] : EC Retail Price Index (1975 = 100)

\[ SPSMP \] : Subsidized price of skimmed-milk powder for animal feed (ECU/tonne)

\[ OPSC \] : Offer price of soya cake (ECU/tonne)

\[ TPM \] : Target price of milk (ECU/tonne)

\[ IPW \] : Intervention price of wheat (ECU/tonne)

\[ GP \] : Producer surplus (milk producers)

\[ GC \] : Consumer surplus

\[ GAF \] : Producer surplus (animal feeders)

\[ GG \] : Government expenditure

NOTES

1. The choice of base policy which is used as the means of comparison does not affect the derived behavioural equations for the policy instruments. Indeed, the absolute levels of producer and consumer surplus could be used. The world price is used purely for convenience of exposition.

2. For a fully consistent estimation of the model, the supply and demand equations should be estimated with the preference function. However, the size of the resulting model makes estimation difficult, and the equations used in the paper have been estimated separately.

3. The equations were estimated using ASIMUL, a pseudo-FIML estimation package written by Wymer (1974).

4. It should be noted that the original model worked only with milk delivered to dairies and so the direct sales quota is excluded from the analysis.
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Summary

The individual farmers' reactions have been threefold; they have made requests for higher quotas; they have filled up the quotas where gaps were available; and they have changed their production structure. The last-mentioned reaction was characterized by a reduction in the number of cows, by the production of more fodder crops and by heifer production in the plain region. Traditional heifer-producers in the mountain area reacted with a higher milk and beef production. As a consequence, the division of labour between plain and mountain regions in milk and heifer production is diminished.

1. Introduction

Switzerland introduced the milk-quota system eight years ago. The purpose of this paper is to report on our experiences and to study its effects. This will be done by examining administrative problems, the politics of agricultural interest groups and the reactions of the producers. Finally, we will analyse governmental behaviour during this period.

The milk-quota system was introduced because the public costs of milk production had become too high. Although it was originally drawn up as a short-term measure, it rapidly became a 'normal' instrument of Swiss agricultural policy.

A short-term evaluation concentrates on the problems of the stabilization of milk-policy costs and the executive problems. If both aspects are fulfilled, people generally consider the measure to be successful. Normally even producer

* The majority of this paper has been drawn from unpublished works by U. Bernegger and L. Meyer, Institute of Agricultural Economics, Zurich.
prices can be raised more than elsewhere. Has this been happening in Switzerland during the last eight years and what have been the long-term effects?

2. Goals of the quota system and the related costs

In 1976, the farmers delivered 2.8 million tons of milk. The aim of the quota system was to reduce this amount to 2.7 million tons. This figure has been increased during the implementation period to 2.9 million tons, and around 3.1 million tons are now distributed as a result of the single quotas. Reasons for this increase will be discussed later.

The public costs for the processing and marketing of the produced milk also increased continuously after the implementation of the quota system. There were cost reductions for a short time, but then costs increased again. Figures 1a and 1b show the increases in amount of milk and the related public expenditures for the utilization of the milk.

3. Behaviour of the participants

The participants of the milk-quota programme are the milk producers, their organizations and the government. Each of these participants behaved in a specific way during the time observed.

3.1. Behaviour and influence of the milk producer organization

The support of the national milk producer organization was essential for implementing the quota system in Switzerland. Traditionally, in Swiss agricultural policy, central organizations are engaged in executing aspects of marketing orders. The organization of milk producers was given the governmental order to implement the milk-quota system. Certainly the government did keep the final decisions concerning the rules for distributing quotas to the individual producers in its hands. But, because of this, the organization of milk producers, of course, had a strong impact upon the rules of distribution. These had to be accepted by both the government and the organization.

The milk producer organization is very heterogeneous. There are groups with different interests, e.g. farmers from the plain region, from the grassland region, from the mountain region as well as the milk processing industry.

Given the fact that the milk production had grown rapidly before the implementation of the quota system, there were farmers with high and those with rather low production levels. This situation in the reference year (1975/76) was the result of a short-run supply reaction of the plain region farmers caused by milk price increases since 1971.

Their local organizations tried to keep this level. They were supported by the
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(a) Market milk production

(b) Public costs

Figure 1. The market milk production and the public costs of their utilization in Switzerland
milk processing industry because the latter had built up its capacities as well. As a result, the most important groups of milk producer organizations obtained **de facto** a distribution of the quotas without reducing the amounts of milk they were already producing. The distorted production structures of 1975/76 became fixed. Some changes in distribution occurred within the local milk cooperatives, by the fixation of an upper limit of milk per hectare which could be delivered. Additionally, for the calculation of the quota per farm, the whole acreage was used to compare the farm’s milk production per hectare with the local cooperative average. This means the more cash crop produced, the larger the absolute milk quota per farm could be requested. By the way, the acreage of vineyards was excluded while the intensive orchards were included! There is no milk lobby in the important wine regions.

The mountain region represents a minority in the national milk producer organization. Therefore their representatives have chosen another way to influence the regional distribution of the quota. They ordered parliamentarians to intervene directly in the parliament and the government. Their intervention was successful, arguing that the incomes of the mountain farmers would decrease because of decreasing prices for heifers which usually are sold by the mountain farmers to their colleagues in the plain region. As a result, the quota system was given up in the mountain region and the milk production went up by one third within the three years! The quota system had to be reintroduced in the mountain region on the correspondingly higher level.

Summarizing, the national milk producer organization has had a strong impact on the total quota and on the manner of the implementation of the system. However, the quota system has also individualized the interest situation of farmers. As a result, there still are individual farmers whose interests are neither covered by their organizations nor by the government. Neglecting this part, both – organizations and government – are satisfied with the implementation of the quota system. But let us now focus on the government’s behaviour.

### 3.2. The role of the government

For implementing the milk-quota system, the government was dependent on the help of the milk producer organization. This means that interests of the dominant producer groups could not be neglected. Otherwise the system would have been jeopardized.

The government’s main goal – as mentioned above – was to cut the public expenditures for rising milk surpluses. During a public voting campaign on this subject the government argued that it would be possible to increase the producer’s milk price after having introduced the quota system. Indeed the milk price was raised between 1976 and 1983 by about 25% in order to partly fulfill the farmers’ income claims. During the same period, export prices for milk products, especially for cheese, have fallen. For these reasons the public expenditures have been growing steadily as shown in Figure 1b.
3.3. The reactions of the individual milk producer

The individual farmers reacted to the introduction of the milk quota system in three ways, namely (1) by requests for higher quotas, (2) by filling up the quotas where gaps were available and (3) by changing their production structure.

First reaction: requests for higher milk quotas per farm

The implementation of the quota system took place in two stages. In the first stage each farmer received a quota based on his production during the reference years of 1974-1976. In the second stage, the former quotas were adapted by taking into account the acreage of the farms and the average milk yield of the local producers' cooperative. The result was a small redistribution of the quotas on the local level.

The second phase, in particular, was accompanied by many request possibilities. It was well known to each farmer, which arguments would be taken into account by evaluating his request. As shown in Table 1, a large number of the 70,000 milk producers asked for higher quotas.

Table 1. Requests and appeals for higher quotas per farm

<table>
<thead>
<tr>
<th>Requests to the:</th>
<th>Year (May-April)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>77/78</td>
</tr>
<tr>
<td>Regional Organization</td>
<td>15000</td>
</tr>
<tr>
<td>1. Commission of Appeal</td>
<td>3000</td>
</tr>
<tr>
<td>2. Commission of Appeal</td>
<td>-</td>
</tr>
</tbody>
</table>

*Source: Sechster Landwirtschaftsbericht (1984).*

This procedure has two aspects: on the one hand cases of undue hardship could be solved, on the other hand many farmers were given higher milk quotas without really needing them. Professional journals supplied the farmer with the information on whether he would qualify for a higher quota or not. The procedure dealt with each farmer in the same manner, but it is questionable whether justice always means equity as well.

An alternative to this closed and well-defined request system would have been an open one with more competence of the request- and appeal-commissions.

Second reaction: filling up the quotas

A result of the chosen request system is that on the individual farms differences between quota and the effective production level often existed. In time, the farmers filled up these gaps for three reasons: First, the possession of a quota is - economically speaking - a property right. It can be capitalized through land sales or rents. Second, the farmers feared losing unused quotas. Third, the milk prices were increased steadily by the government, so that milk production
became more and more profitable. Summarizing, it can be said that the reactions of the farmers are economically explainable.

Third reaction: changes in the agriculture structure

The changes in the agricultural structure after having introduced the milk-quota system are the theoretically expected ones. Some of these changes are discussed here. To understand the observed changes, we need some basic information about Swiss agriculture: Milk production is about 31%, beef production 19%, hog production 19%, and cash crops about 8% of total agricultural production value. The regional distribution is governed by natural conditions. In the plain region we have predominantly milk production, beef production and cash crops. The farmers in the mountain region produce heifers and milk. The heifers are sold to milk producers in the plain areas. As a result, the reactions in these two main regions differ strongly.

With a regional dynamic simulation model (Bernegger, 1984; Lehmann, 1984) we isolated the influence of the milk-quota system. The results of this model explain very well the changes in the use of farm acreage. The plain farmers mainly increase fruit plantations, partly cash crops and also hog production. We point out that the production of fodder crops for own farm use increases heavily. Sugarbeet and rape acreage extend according to the increase of the quotas given for these products.

The changes in the dairy and beef herds during the six years between 1978 and 1983 are very important. Table 2 contains some indications. We have to

Table 2. Development of cattle-herd structure in the plain and mountain region, 1978–1983

<table>
<thead>
<tr>
<th>Herd structure 1978</th>
<th>Switzerland</th>
<th>Plain Region</th>
<th>Mountain Region</th>
</tr>
</thead>
<tbody>
<tr>
<td>cattle</td>
<td>2,023,700</td>
<td>77.5%</td>
<td>22.5%</td>
</tr>
<tr>
<td>cows</td>
<td>892,800</td>
<td>80.2%</td>
<td>19.8%</td>
</tr>
<tr>
<td>heifers</td>
<td>167,100</td>
<td>64.1%</td>
<td>35.9%</td>
</tr>
<tr>
<td>beef production</td>
<td>184,700</td>
<td>96.8%</td>
<td>3.2%</td>
</tr>
<tr>
<td>rearing rate</td>
<td>0.19</td>
<td>0.15</td>
<td>0.34</td>
</tr>
<tr>
<td>Changes 1978–1983</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>cattle</td>
<td>-4.5%</td>
<td>-5.3%</td>
<td>-1.6%</td>
</tr>
<tr>
<td>cows</td>
<td>-5.5%</td>
<td>-7.2%</td>
<td>+1.4%</td>
</tr>
<tr>
<td>heifers</td>
<td>-6.1%</td>
<td>-3.6%</td>
<td>-10.4%</td>
</tr>
<tr>
<td>beef production</td>
<td>+8.4%</td>
<td>+6.1%</td>
<td>+78.0%</td>
</tr>
<tr>
<td>rearing rate</td>
<td>-0.6%</td>
<td>+3.9%</td>
<td>-11.7%</td>
</tr>
</tbody>
</table>

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distinguish between the plain and the mountain region. The plain farmers reduced the number of cows by 7%. Their rearing rate per cow and their beef herds increased. The farmers in the mountain region reacted in two ways: to compensate for the reduced sales of heifers, they initially increased the milk production as long as they were free to do this. After the introduction of the quota system in the mountain region in 1981, they increased the beef production. This was the only way to use their grassland, although neither the farmers nor the natural conditions are well suited for this production. It is a short-term reaction of relatively immobile farmers to an implemented coercion. For political reasons, the government has to prevent a decrease in the income of the mountain farmers and therefore it increases the subsidies for the growing but inefficient beef production in the mountain area.

We may summarize our observations as follows: The farmers in the plain region increase their self-sufficiency on fodder crops and heifers which means a loss of efficiency by giving up an economic division of labour between plain and mountain regions. The consequences are higher production costs for beef and milk. The mountain farmers increase production branches which, considering comparative costs, are uneconomical. At the same time surpluses of products other than milk arise. The costs to subsidize those products are increasing as well, and in the long run the social costs also increase.

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