Manchester Working Papers in Agricultural Economics

AN ECONOMETRIC MODEL OF THE UK AGRICULTURAL SECTOR

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(WP 87/02)

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INTRODUCTION

The estimation of structural econometric models of sectors of UK agriculture has become well established in the UK, not least within the Department of Agricultural Economics at Manchester. In the past each study has tended to concentrate on individual sectors in isolation, often with different periodicities, data definitions and methodological approaches, although there have been efforts to bring the work together into a single model of UK agriculture (see, for example, Colman and Young (1981)). The current project, financed by the Ministry of Agriculture Fisheries and Food, has required the construction of a model of UK agriculture covering all sectors, both input and output, which is suitable for policy simulations. The specific objective of the project has been for the model to generate results in the form of the Output, Input and Net Farm Income Table of the Annual Review (Table 22 of the 1986 edition). This requirement has meant that each component of the model has to be consistent (in terms of definitions etc.) in order for it to be run as a system, with all of the interlinkages operational. This has meant that all sectors of the model have had to be constructed specifically for this project; although there has been the usual reliance upon previous studies in the specification of some of the sectors.

The requirement of generating calendar year forecasts of the input and output values has imposed certain restrictions on the way in which the modelling has been conducted. The calendar year often does not correspond to the natural harvest year involved in crop production, and it also cuts across some important institutional time periods (e.g. the milk year relevant for calculating the milk quota, the harvest year relevant for cereal intervention prices and the dates of the census). The extent to which these problems have been overcome has varied between sectors. Where possible semi-annual data has been used, defined on a Jan-Jun : Jul-Dec basis, allowing calendar year values to be determined. In others, where annual data alone is available (eg cereal production) annual models have been used in conjunction with some technique for allocating sales between two calendar years (eg year-end stock equations).

The combination of annual and semi-annual data in a single model can cause problems in simulation, where all sectors have to be run simultaneously. The method adopted in this study is to run the model on a semi-annual basis with "annual" equations being switched on and off by seasonal dummies, generating a value in one period (typically the second) and a zero in the other. With careful redefinition of the lag structure, the annual models run in this "semi-annualised" form produce identical results to the same equations run on an annual basis. The method has the advantage that any variable needed in an annual model which is generated in a semi-annual model (ie a price) can be made available by a suitable weighting procedure and any semi annual model that uses an annual variable (ie a cereal yield in a price equation) can also 'collect' the relevant value by careful definition of the lag structure.

The modelling technique used follows the "directly estimated single commodity supply model" technique (or 'informal' technique) as descibed by Colman (1983), in which the supply response is not derived from any formal consideration of an optimization problem subject to technical constraints, but rather is derived by directly estimating reduced form equations for the supply of each product. These need not be a single equation per sector, but may consist of several where there are clear intertemporal linkages (i.e. in the livestock sectors) or where supply is split into its components of yield per unit and unit numbers. The only exception to this sector by sector approach is where a group of closely related commodities are modelled within the context of a system of share equations (using the multi-nomial logit technique) but this is still within the framework of a behaviouraly informal method, with some restrictions placed upon the parameters of the equations. The quantities of the inputs used are related directly to the supply sector that utilizes the input. In this way one achieves some consistency between the two.

Interaction between sectors occurs via the system of price equations. Own and competing output prices are present in all supply sectors, and the output prices of some sectors appear as input prices in others. The price equations themselves are estimated using the same informal technique as for supply, and in general contain output or input quantities, and institutional prices. In this way a change of an exogenous variable in a particular sector will have knock-on effects through into other sectors via the determination of the relevant prices. As Colman (1983) notes, the degree of stability in such a system of supply equations is not imposed by restriction, but derives from the accuracy of the estimated equations and extreme variations in exogenous variables may not generate a robust response.

The emphasis on reproducing Table 22 format output means that some aspects of UK agriculture do not have to be addressed. These include explicit reference to the demand for the outputs (although these are dealt with implicity in the price equations) and export of the products does not have to be seperatly identified, but can be subsumed into output as a whole.

At the time of writing (March 1987), the coverage of the model is not yet complete, in fact there are some important areas that have not been fully investigated. The bulk of the outputs have been covered, and detailed reports of these are included in the following chapters. Some minor crops have had to be modelled using simple ARIMA or time trend models, but this being said, the values of 17 outputs can be identified, and it is possible to disaggregate some of these further if required.

The input side of the model is the area where the largest gaps exist. Only the feedingstuffs sector has been modelled with any sophistication, although some extensive work on fertilizer has been tried, but did not yield any useful results. However, a simple specification has been implemented. Feed and fertiliser account for some 60 percent of gross input value. The remaining elements have been modelled either by simple time trend models, or linked to some aggregate value generated elsewhere in the model. These equations have been reported in a separate chapter, with the minor crop equations.

The decomposition of net product into its component parts has also to be completed, although the specification of the equations appears straightforward, following established econometric work in the areas of labour employment, bank lending to agriculture and land rental value.

All product prices and the feed input prices have been modelled, and are reported in chapter 9 of this report. There remains the task of modelling the prices of the inputs that have not been fully modelled (e.g. fertiliser, seeds etc).

Even in its current incomplete state, the size of the model is considerable, running to some 200 equations (although in its extended form it would be in excess of 400 equations), and it is anticipated that in its completed form it will contain some 300 equations. Manipulation of such a model is cumbersome, and it is currently being used on a main frame computer at Manchester, although softwear of sufficient power now exists for it to be loaded onto a PC. Evaluation of the model has been done via simulations of the sectors in isolation, as well as by simulations of the full model, with emphasis being placed on the models ability to reproduce the relevant values drawn from Table 22. The results from such a full simulation are contained in Chapter 11, for the period 1978 to 1982, and provide a basis for confidence in the model's ability to be a useful tool for policy analysis. However, it also needs to be able to respond to changes in the policy environment of UK agriculture. In this context the introduction of milk quotas just prior to the commencement of this project has required some adjustment in the manner in which the dairy sector supply response is modelled. Full details of the method used are given in Chapter 4, but it is of interest to note here that it is possible to conduct an analysis of the impact of the recently announced changes in the level of the milk quota, and some provisional results of this are also reported in Chapter 11. The model is already proving to have uses outside the narrow confines of the Net Farm Income Calculation. Research at Manchester period 1987 to 1991, with attention again being primarily upon the changes in the respective values, although some discussion of the changes in the underlying physical and economic variables is also given.

These simulations give an indication of the sort of policy analysis that the model makes possible. They also show that the model is in some sense robust, in that the within period simulations track the actual values with an acceptably high degree of accuracy, and the policy simulations, which cause exogenous shifts in some policy variables, result in plausable changes in the various sectors. This result is not a trivial one when several, separatly estimated, models are brought together into a single unit, comprising some 200 equations with a high degree of interdependence.

Chapter 1

THE CEREALS SECTOR

(T Young)

Introduction

The three cereals within the model have been estimated jointly, as a system, using the Multi-Nomial Logit approach to explain the areas planted to each of three cereals. Yield equations are also estimated, with yield per hectare as a function of time and weather variables. A particular problem with cereals is that the calendar year sales will consist of the output from two harvest years, so there is a need to determine the quantity of a harvest that is sold in the initial months of the harvest year (i.e. from harvest to the end of December). This is done by estimating year-end on-farm stocks. The equations have been estimated with annual data, for the period 1965 to 1983, although in some cases a shorter period has to be used. In the following sections a general description of the model is given, with more detailed results in the appendix.

Area equations.

An implicit assumption of the approach is that producers undertake a two stage decision making procedure.

(i) the total hectarage to be devoted to cereals is determined
(ii) the grains allocation is then divided among the individual cereals.

At the upper level the total area of cereals grown is specified as a function of the average cereal return per hectare, deflated by the harvest year index of fertiliser prices, lagged one year. The (lagged) ratio of the oilseed price to the fertiliser price was also found to be significant. The inclusion of a lagged dependant variable implies some partial adjustment mechanism towards equilibrium. The returns to other alternative activities, particularly milk and beef production, were also included in some specifications, as it was thought that there should be important inter-linkages between these sectors, but no significant relationships were found.

In the second stage the shares of the different cereals within this total are determined. In problems of this nature it is highly desirable that not only the actual shares but also the estimated or predicted shares are non-negative and sum to unity i.e. the shares behave as probabilities. While many specifications can be used to ensure that the shares sum to unity, the dual restrictions of adding up and non-negativity require the use of highly non linear equation systems. A model that does fulfill these requirements is Theil's multi nomial extension of the linear logit model.

For our purposes, cereals are classified into wheat, barley and 'other cereals' (oats, rye and mixed corn). Let A_i denote the hectarage of cereal type i and TA total area of cereals. The share of total area planted in cereal i (W_i) is then

$W_i = W_i/TA$ and it is hypothesised that

$$W_i = \frac{e^{f_i+u_i}}{\sum_{j=1}^{n} e^{f_j+u_j}} \qquad i=1,2,3 \qquad (1)$$

Various experiments on the specification of f_i have been undertaken. The form used for the final model is as follows:

$$f_i = a_0 + b_{i1}Ln(RW.1/RB.1) + b_{i2}Ln(RO.1/RB.1) + b_{i3}Ln(RAIN.1) + b_{i4}Ln(TA) \qquad (2)$$

Where RW.1 = Returns per hectare of wheat in the previous year; RB,RO are defined conformably.

RAIN.1 = Rainfall level at time of planting.

The rainfall variable is used to capture the effect that a wet autumn may have on cultivations, which may mean that the desired allocation (determined on the basis of relative returns) may not be achieved if there are physical constraints. In fact the results indicate that heavy autumn rainfall results in less wheat plantings and greater (presumably spring) barley plantings.

Each equation in (1) has three disturbance terms (u_i) and indeed the nature of the denominator implies that all variables and disturbances affect all equations even if some restrictions are placed on some of the f_i. In order to estimate the system, a transformation which uses the property that each equation shares a common term, is required. A useful transformation is obtained as follows:

Let $Ln(W^{\sim}) = 1/3 \sum Ln(W_i) = f^{\sim} + u^{\sim} - Ln(\sum exp(f_j + u_j))$

Where $f^{\sim} = 1/3\sum f_i$

$u^{\sim} = 1/3\sum u_i$

Then,

$$Ln(W_i/W^{\sim}) = (f_i - f^{\sim}) + u_i - u^{\sim} \qquad (3)$$

$$= A_0 + B_{i1}Ln(RW.1/RB.1) + B_{i2}Ln(RO.1/RB.1)$$

$$+ B_{i3}Ln(RAIN.1) + B_{i4}Ln(TA) + v_i \qquad (4)$$

Where A_i and B_{ij} are the deviations of a_i and b_{ij} from their means. This factor makes the interpretation of the estimated parameters difficult, but elasticities are easily calculated.

As the same variables appear in each equation, OLS, Seemingly Unrelated Regression or Maximum Likelihood are identical. It should of course be noted that the systems estimators require some modification since the three disturbances in (4) are perfectly correlated implying a singular covariance maxtrix. The standard approach is to delete an equation before estimation.

Although the model depicted by (4) provides a reasonable fit to the data, there is some evidence of misspecification which can be attributed to the model's static nature. A number of experiments with general dynamic specifications were performed but the version of the model that appears to be most appropriate contains a single lagged dependant variable in each equation. It can be shown that in a system wide model with a single lagged dependant variable in each equation, the coefficient on the lagged dependant must be the same across equations. In order to impose this restriction, a ML estimation procedure is required.

Yield Equations

In supply models, crop yields often prove difficult to model. Yield response is, inter alia, a function of weather, technical progress in seed varieties, fertiliser application and management, but typically the specification of an estimating equation will be constrained by data availability. Here a reasonable fit is achieved by simply regressing yields of each of the three cereals on a weather variable (average daily sunshine in June, July and August) and a time trend. As wheat yields show a particularly rapid growth after 1973, a dummy variable is included to capture this effect.

Stocks on Farm Equations

The starting point for this phase of the analysis is a simple accelerator model of the form:

$$STOCKS = a*PRODUCTION \qquad 0<a<1$$

Where STOCKS is defined as the on farm stocks at the end of December.

As sales off farm to December would be defined as the difference between production and end of year stocks, the calendar year sales are defined as:

$$SALES = (1-a)PRODUCTION + STOCKS.1$$

The stocks equation was fitted for each of the cereals. For wheat and oats a reasonable fit was achieved since in both cases the proportion of output stored has been approximatly constant over the data period. For barley however, the relationship between stocks and production breaks down after the mid 1970's i.e. the proportion of production stored falls markedly. Possibly this development reflects the increased attractivness of selling into intervention as the barley market has collapsed, encouraging sales into intervention rather than storage. The inclusion of relative seasonal prices, and the intervention price, have not produced significant results, although using the barley intervention stocks and a time trend did give significant improvements. The degree to which these are genuine rather than spurious relationships is difficult to say, but further work on the stock holding decision is needed.

Simulation Results.

When the full cereals model is simulated within the data period the overall impression, judged by Theil U(2) coefficients for the quantities within the model, is quite encouraging (see Table 1.1 below). However, when we examine percentage forecast errors in the last 5 years, it is apparent that some specification errors remain. Table 1.2 below presents a comparison between DNIC quantities over the period 1978/83 and the projected quantities provided by the model. An initial problem is the definition of the calendar year sales used in DNIC. If one takes a simple definition i.e.

SALES = STOCKS.1 + PRODUCTION - STOCKS

there are substantial discrepancies between the figures reported in Output and Utilization and those in the Departmental Net Income Calculation. The cause of these errors appears to be the need to make some correction for seed and waste on farm, and a correction for feed grain movements. In the absence of precise data on the latter, a residual variable was defined to ensure corresponance between the data sets, and then this residual defined as an exogenous variable, i.e.

SALES = STOCKS.1 + PRODUCTION - STOCKS - RESIDUAL

Table 1.1

Theil U(2) Statistics for Selected Variables in the Cereals Model

Area Wheat	0.757
Area Barley	0.912
Area Oats	0.668
Sales Wheat	0.619
Sales Barley	0.586
Y.E. Stocks Wheat	0.547
Y.E. Stocks Barley	0.422

Table 1.2

Comparison of Actual and Simulated Calender Year sales of Wheat

	DNIC	SIMULATED	% ERROR
1978	5241	5606	7.0
1979	6300	6426	2.0
1980	7910	7297	-7.7
1981	7847	8171	4.1
1982	9993	8502	-14.9
1983	8968	8898	-0.8

Table 1.2 cont.

Comparison of Actual and Simulated Calender Year sales of Barley

	DNIC	SIMULATED	% ERROR
1978	7013	6454	-8.0
1979	6206	6719	8.3
1980	7014	6856	-2.2
1981	8074	7331	-9.2
1982	8233	7702	-6.4
1983	6981	7972	14.2

For wheat and barley, the principle source of forecast error appears to be the on-farm stocks equations and further work on these specifications seems to be required. The results of 'other cereals' (not presented) appear rather less satisfactory but this is due mainly to the definition of the variables used, namely, the area of 'other cereals' comprises the hectarage of oats, rye and mixed corn, whereas on farm stocks and yield refer to oats only.

The definition of the value of production is achieved by multiplying the sales in each half of the calendar year (assumed to be the stocks in the previous December for the first half and production less current year-end stocks for the second half) by the relevant semi-annual price index. For wheat and oats this is then normalised onto the 1980 reported value of sales so that the index of values is converted back into nominal terms. If this is done for barley, although there is an exact fit for 1980, there appears to be a consistent overestimate in the other years, so a further adjustment is made to allow for this. A comparison of the actual values and the accounting values so generated are reported below.

Table 1.3

Comparison of Actual and Accounting Values for Wheat, Barley and Oats

	WHEAT		BARLEY		OATS	
	Actual	Acc.	Actual	Acc.	Actual	Acc.
1974	282.7	287.5	319.2	313.7	17.1	21.4
1975	296.3	289.9	328.7	310.8	15.4	20.0
1976	317.6	325.2	377.6	383.9	19.8	20.1
1977	365.6	363.9	414.2	389.4	21.6	28.1
1978	450.2	465.0	549.1	549.8	20.8	21.8
1979	605.2	606.5	557.2	556.2	21.5	19.1
1980	785.5	785.5	651.2	631.2	25.9	25.9
1981	855.0	850.9	811.0	819.9	28.0	25.9
1982	1137.0	1144.9	894.0	908.4	31.0	24.4
1983	1123.0	1142.2	836.0	867.1	30.0	21.9

In general the performance of the area allocation model is good, but there are problems with determining the year-end stocks. As these are important in determining the value of the calendar year sales, this would seem to imply that problems may be encountered in generating accurate year on year forecasts. The problem will be offset to some extent at the level of gross output, or beyond, as the value of the physical change in stocks will compensate for any under/over estimate of calendar year sales.

Appendix 1.1

TOTAL CEREAL AREA EQUATION

```
TA  =  1275  +  0.711*TA.1  +  89.8*RETC.1/FERTP$H.1
      (2.52)   (5.58)          (1.71)

                 -  348*POS.1/FERTP$H.1
                   (3.52)
```

R BAR Squared = 0.818
F Test (3,12) = 23.5
D.h = 0.679
d.f. = 12
D.V.Mean = 3812

CEREAL ALLOCATION EQUATIONS

		Cereal	
	Wheat	Barley	Oats +
Intercept	-5.998 (1.81)	-0.891 (0.36)	6.89 (2.18)
Lagged Dependant	0.841 (15.13)	0.841 (15.13)	0.842 (15.13)
Ln(RW.1/RB.1)	0.260 (1.32)	0.137 (1.10)	-0.397 (3.84)
Ln(RO.1/RB.1)	-0.283 (1.25)	-0.317 (2.13)	0.600 (3.84)
Ln(EWRAIN$SEP)	-0.048 (1.94)	0.049 (2.98)	-0.002 (0.13)
Ln(TA)	0.754 (1.87)	0.095 (0.31)	-0.848 (2.19)

LLF = 72.6

WHEAT YIELD EQUATION

$$WHEATY = -5.33 - 2.20*DUM73 + 2.94*EWSUN\$JJA - 0.239*EWSUN\$JJA^2$$

(2.40) (3.91) (4.17) (4.37)

$$+ 0.045*TIME\$A + 0.145*DUM73*TIME\$A$$

(3.91) (4.92)

R BAR Squared = 0.92
F Test (5,20) = 55
D.W. = 2.46
d.f. = 20
D.V. Mean = 4.45

BARLEY YIELD EQUATION

$$BARLEYY = -1.20 + 1.44*EWSUN\$JJA - 0.121*EWSUN\$JJA^2 + 0.059*TIME\$A$$

(0.78) (2.96) (3.19) (10.57)

R BAR Squared = 0.80
F Test (3,22) = 34
D.W. = 2.00
d.f. = 22
D.V. Mean = 3.80

OAT YIELD EQUATION

$$OATY = -1.85 + 1.46*EWSUN\$JJA - 0.122*EWSUN\$JJA^2 + 0.076*TIME\$A$$

(1.53) (3.82) (4.12) (18.55)

R BAR Squared = 0.92
F Test (3,22) = 101
D.W. = 1.95
d.f. = 22
D.V. Mean = 3.80

STOCKS ON FARM EQUATION: WHEAT

```
STDECW  =  547.0   +  0.439*PRODW
          (1.35)     (7.98)
```

R BAR Squared = 0.862
F Test (1,9) = 63.7
D.W. = 2.53
d.f. = 9
D.V. Mean = 3647

STOCKS ON FARM EQUATION: BARLEY

```
STDECB  =  -108*TIME$A  +  0.694*PRODB  -  1.142*STOCKSIB
           (2.6)           (7.85)          (3.78)
```

R BAR Squared = 0.995
F Test (3,8) = 758
D.W. = 2.00
d.f. = 8
D.V.Mean = 4164

Variable definitions

RETC	=	Returns per hectare for cereals, being a weighted average of the individual crops.
FERTP$H	=	Price index of fertiliser, harvest years.
POS	=	Price index of oil seed rape.
WAREA	=	Area of wheat.
BAREA	=	Area of barley.
OAREA	=	Area of oats, rye and mixed corn.
WHEATY	=	Yield of wheat.
BARLEYY	=	Yield of barley.
OATY	=	Yield of oats.
RW	=	Return per hectare to wheat, defined as harvest year price times WHEATY.
RB	=	Return per hectare to barley, defined as harvest year price times BARLEYY.
RO	=	Return per hectare to oats, defined as harvest year price times OATY.
EWRAIN$SEP	=	Average daily rainfall in September.
TA	=	WAREA + BAREA + OAREA.
DUM73	=	Dummy variable, =1 from 1973, 0 prior to 1973.
TIME$A	=	Annual time trend.
EWSUN$JJA	=	Average daily sunshine in June, July and August.
STDECW	=	Stocks on-farm at the end of December, for wheat.
STDECB	=	Stocks on-farm at the end of December, for barley.
PRODW	=	WAREA*WHEATY.
PRODB	=	BAREA*BARLEYY.
STOCKSIB	=	Intervention stocks of barley.

Chapter 2

THE SUGAR BEET AND POTATO MODELS

(J Martin)

These two sectors are reported together, as the use of a Quota system in each is the main determinant of the area planted to the crop, the manner in which the value of the output is strongly dependent upon weather (and hence yield) variations is common to both, providing common difficulties in forecasting future values. Both models are restricted by very short, annual, data periods. Where possible semi-annual equations have been used, and these are noted in the text. Otherwise annual forms are used.

Sugar Beet

The review by Rayner et al (1986) has indicated the complexity of the institutional arrangements involved in supporting the Sugar Beet sector. The common EEC support instruments of intervention prices, variable import levies etc apply, but they apply to the processed product of sugar, rather than directly to the beet itself. Furthermore, a system of quotas is used to limit the responsibilties of the intervention agencies in supporting the market, with these quotas again being fixed in terms of sugar. The quota system is two tiered. "A" quota is set at approximatly Community demand level, and is fully supported by the intervention system. "B" quota has a production levy attached to it, as a contribution to the costs of disposing of the product on world markets. This levy varies inversly with the world price, up to some maximum limit, implying that it is possible for the costs of disposal to exceed revenue raised. In these cases the uncovered cost is 'rolled over' to the following year. Any production over the sum of "A" and "B" quota receives no support and has to be disposed of on the world market unsuported. This degree of complexity in a system would prove difficult to incorporate into any econometric model, and, given the sectors' small relative size (approx. 2% of final output), the model presented below has attempted to incorporate only the major features of the system, and not the detail. A general description of each equation is given in the following sections, with detailed results in Appendix 2.1.

Area Equation

The overall Quota restriction is in terms of refined sugar, and the tonnage that farmers are contracted to grow is in terms of 'adjusted' tonnes, where the expected sugar content is equal to 16%. If the delivered beet has a sugar content different to 16% then the delivered tonnage is adjusted according to a sliding scale. The area planted is therefore perceived to be a function not only of the UK refined sugar quota level, but also of an average beet yield and average sugar content. These are combined to give an implicit acreage quota, defined as:

$$AREAQ = \frac{SBQUOTA}{MASC.MAYIELD}$$

where SBQUOTA = sugar quota

MASC = 3 year moving average of refined sugar content

MAYIELD = 3 year moving average of beet yields

Other explanatory variables are the relative prices of sugar beet and barley. Relative returns were also used, but the current specification was superior. A lagged dependent variable allows for some partial adjustment to changes in the exogenous variables.

Yield Equation

The only significant determinants of the sugar beet yield were weather variables. These have been defined for East Anglia rather than at the national level, as this is the predominant production area. The yield has a quadratic response to rainfall in August and September, with higher rainfall increasing yields, but at a declining rate, with the maximum effect occuring at approximately average conditions. A similar effect is observed for the ratio of the sun and rain in August, with the maximum yield occurring at above average conditions. No significant price effects or time trend were detected.

Sugar Content Equation.

As the return to farmers is determined not only by the yield of the beet, but also its quality, an equation explaining the sugar content has been estimated. Sugar content is determined by the sunshine in August, again with a quadratic form, and the level of rain in September. There is also a significant time trend over the period.

Sugar Beet Return Equation.

The definition of the dependent variable is the return to the farmer per tonne of beet delivered. Not surprisingly, the Minimum Sugar Beet price is the main determinant. In an effort to capture some quality effect, the sugar content has been included, which is significant and positive as expected, implying a higher content gives a higher price per tonne. The effects of over quota production is dependent on whether the world price is greater or less than the Intervention price. If it is less, then over-production has to be exported at world prices, implying a reduction in average returns. The effect should follow a step function, i.e C quota production should reduce prices more than B quota production. Given the low degrees of freedom a composite variable, defined as excess production multiplied by the difference between world and intervention price, was used, and had the expected impact.

Refined Sugar % Equation.

In order to determine the implied area quota one has to convert the white sugar quota into the equivalant beet tonnage. This is done using a refined sugar content, which will give the quantity of refined sugar from a tonne of beet. This is closely related to the basic sugar content used to determine the farmers returns, but there appears to be some positive trend also, presumably implying a greater efficiency in extraction.

Simulation Results

The model has been simulated for the period 1973 to 1982, using endogenous yields. These results appear to be good, but for some years (1977,1978 and 1979) the crop value estimates were not good. Inspection of the results indicated that the yield equation did not perform well in those periods. The model was re-simulated, but holding yields exogenous, and this substantialy improved the estimates for the value of production. This reveals that the basic structure of the model may be sound, but that the Value of production is largly determined by yield levels, which in turn are determined by the weather. This will naturally be a constraint upon the models' ability to forecast ex-ante.

Table 2.1

Theil U(2) Statistics

	Exogenous yields	Endogenous yields
SBAREA	0.73	0.81
SBYIELD	----	0.26
SBPRICE	0.38	0.38
SCONT	0.25	0.25
SBPROD	0.08	0.32
SBVALUE	0.32	0.47

Appendix 2.1

AREA EQUATION

$$SBAREA = \underset{(1.92)}{38.45} + \underset{(2.35)}{0.0296*AREAQ} + \underset{(6.29)}{0.709*SBAREA.1} + \underset{(1.70)}{54.34}*\frac{SBPRICE.1}{BARLEYP}$$

R BAR Squared = 0.855
F TEST (3,11) = 28.56
D.h. = 0.215
d.f. = 11
D.V. Mean = 198.4

BEET YIELD EQUATION

$$SBYIELD = \underset{(2.00)}{10.64} + \underset{(3.59)}{0.394*EARAIN\$AS} - \underset{(4.17)}{0.0022*EARAIN\$AS^2}$$

$$+ \underset{(2.74)}{4.39*EASUNRAIN\$AUG} - \underset{(3.53)}{1.11*EASUNRAIN\$AUG^2} + \underset{(7.68)}{0.0004*EARAIN\$APR^2}$$

R BAR Squared = 0.890
F Test (5,10) = 29.75
D.W. = 1.83
d.f. = 12
D.V. Mean = 34.89

SUGAR CONTENT EQUATION

$$SCONT = \underset{(4.48)}{9.64} + \underset{(1.99)}{0.04*TIME} + \underset{(3.52)}{0.147*EASUN\$AUG} - \underset{(3.71)}{0.0007*EASUN\$AUG^2}$$

$$- \underset{(3.57)}{0.011*EARAIN\$SEP}$$

R BAR Squared = 0.73
F Test (4,13) = 12.66
D.W. = 2.00
d.f. = 13
D.V. Mean = 16.22

SUGAR BEET PRICE EQUATION

$$SBPRICE = \underset{(3.09)}{-18.28} + \underset{(11.7)}{0.746*MINSBP} + \underset{(4.35)}{1.685*SCONT} - \underset{(2.55)}{0.0002*WPOVERP}$$

R BAR Squared = 0.96
F Test (3,6) = 83.26
D.W. = 2.37
d.f. = 6
D.V. Mean = 21.1

REFINED SUGAR CONTENT EQUATION

RESCONT	=	-0.0486	+	0.0112*SCONT	+	0.0005*TIME
		(2.81)		(10.56)		(2.93)

R BAR Squared = 0.89
F Test (2,14) = 62.71
D.W. = 0.82
d.f. = 14

Variable Definitions

SBPROD = Beet production.

SBAREA = Area of sugar beet recorded in June census, less 1000ha for seed.

SBYIELD = SBPROD/SBAREA.

SBPRICE = Return from beet, defined as Value/Production in Output and Utilization.

SCONT = Sugar content of beet.

REFSCONT = Refined sugar content, defined as refined output/beet production.

BARLEYP = Price index for barley, harvest years.

MSBP = Minimum sugar beet price.

MASC = 3 year moving average of REFSCONT.

MAYIELD = 3 year moving average of SBYIELD.

SBQUOTA = GB quota of refined sugar.

AREAQ = Perceived acreage quota, as defined in the text.

INTP = Intervention price of refined sugar.

WP = World price of refined sugar.

WPOVERP = (SBPROD*REFSCONT-QUOTA)*(INTP-WP).

EARAIN$AS = East Anglia rain, average for August and September.

EASUNRAIN$AUG = Ratio of East Anglia sun to rain in August.

EARAIN$APR = East Anglia rain in April.

EASUN$AUG = East Anglia sun in August.

EARAIN$SEP = East Anglia rain in September.

POTATO SECTOR

Introduction

In common with the sugar beet sector, the potato sector is dominated by quota restrictions, and the weather. The sector sees substantial variations in yield and in price over time, and although it is possible to explain these large variations to a high degree, the good 'fit' of some of the equations hides some fairly large errors for particular periods. This, combined with the usual problem of forecasting with a model which is largly dependent upon weather variation, means that the sector is likly to be of more use for forecasting general trends rather than values for a particular year.

In the following sections a brief description of each equation is given, with more detailed results presented in Appendix 2.2.

Area Equation

The area of potatoes planted is defined for Great Britain only, for the maincrop, with Northern Ireland and early potatoes being modelled in separate equations. Over the relativly short data period available (1974 to 1984) the target area has not always been binding, or fullfilled. Thus, although the target area is an important determinant of area, there is also some scope for the relative returns per hectare between potatoes and wheat (lagged one period) to affect the area, and there is some partial adjustment towards the equilibrium implied by the lagged dependent variable.

Potato Yield Equation

The potato yield is defined as a function of weather variables, with June sunshine having a quadratic form, implying an initial positive response, but which then becomes negative as drought conditions develop. Transpiration variables are also used, defined as the ratio of temperature to rainfall, with the expected effect of greater rainfall giving higher yields. The fit of the equation is high (94%) and all of the turning points are captured.

Movement into Human Consumption Equation

Data on movement into human consumption is available on a semi-annual basis, and this has been used in order to expand the degrees of freedom within the equation. The harvested quantity of potatoes affects the quantity in both periods of that harvest year, although it has a different effect in each period as a result of using a seasonal dummy. A variable defined as the quantity of potatoes removed from the market by the Potato Marketing Board operations when prices are weak has the expected -ve effect on movement, as does a dummy variable defined as zero in the first period of the harvest year (second period of the calendar year) and the ratio of movement in the first period to the quantity harvested. The effect of this variable is to allow movement in the second period to fall if there was an above average movement into human consumption in the first period. Some experiments were made with relative prices, to see if the seasonality of movement into human consumption was affected by actual or expected seasonality in prices. No significant effects were found.

Main Crop Potato Price Equation

This equation has also been estimated using semi-annual data. Although one could determine price on the basis of movement into human consumption, simulations of the model using this specification tended to be inferior to those where prices are a function of harvested quantity. The reasons for this are unclear. Also, some considerable effort was expended on including such relevant variables as European yields, and relative prices in the previous year as a measure of expected prices. However, a much simpler specification was eventually used, which performed well within the overall context of the model. This simply related (undeflated) price to the RPI, production of potatoes and a seasonal dummy. It could be that this specification captures the essential features of the market without over-burdening the estimation.

Early Potato Area Equation

The area of early potatoes follows a simple partial adjustment framework, using the deflated early potato price (defined as the average potato price in June and July) lagged one period as the explanatory variable.

Early Potato Movement into Human Consumption.

This variable proved difficult to model, with practically no correlation between it and the production of early potatoes. The final specification uses a trend, and lagged real early potato prices. As this is a fairly minor element as compared to the main crop this was thought satisfactory.

Early Potato Price Equation

The early potato price is determined by the quantity of early potatoes produced, and also the (lagged) relative returns of early potatoes to the potatoes sold in the second half of the year. The justification for this is that the definition of early potatoes is not clear cut, and that changes in relative prices in previous years may result in shifts in the marketing pattern of potatoes that would otherwise be sold as main crop in the second half of the calendar year, and that this affects the current year price.

Northern Ireland Area of Potatoes Equation

A simple partial adjustment equation is used, with a lagged relative returns variable having the expected positive effect on area. This returns variable is defined as the NI potato returns per hectare deflated by cereal returns per hectare.

Northern Ireland Yield, Price and Quantity Equations

Due to their minor nature in the sector, very simple equations have been used for these elements, which simply link prices and yields to the mainland values, and allow area to respond to lagged NI returns deflated by cereal returns.

Potato Value Equation

The potato value has been derived as a combination of the annual figures for the early and NI production, and the annual calendar value for the main crop potatoes calculated from the respective semi-annual values. The accounting value generated in this way showed substantial deviations from that reported in the DNIC. A possible cause of this would be adjustments made to the DNIC value as a result of estimates of unrecorded sales, sales of seeds, adjustments to prices to allow for the value of sacks etc. Given these wide variations it was thought unwise to simply normalise the value on one year as is done for most other sectors, but instead we regressed the accounting index against the actual value to give estimated adjustment coefficients. Table 2.2 below gives the actual and accounting values generated by this process.

Table 2.2

Comparison of Actual and Accounting Values for Potatoes

	ACTUAL	ACCOUNTING
1974	150.0	151.3
1975	327.7	309.9
1976	585.0	566.6
1977	376.0	366.9
1978	260.5	256.8
1979	385.1	374.9
1980	311.8	330.7
1981	391.7	408.4
1982	451.2	462.1
1983	495.0	506.3

The simulation performance of the model is quite good: as can be seen from the plots of actual against simulated for the semi annual price and movement into human consumption, the major turning points in the series are caught, but there are periods (e.g. 1976 period 1) where there are still substantial errors being made. These then reflect in the simulated values, which, in 1976 has an error in excess of 10%, and for 1983 an error of some 20%

Fig 2.1 SEMI ANNUAL POTATO PRICE

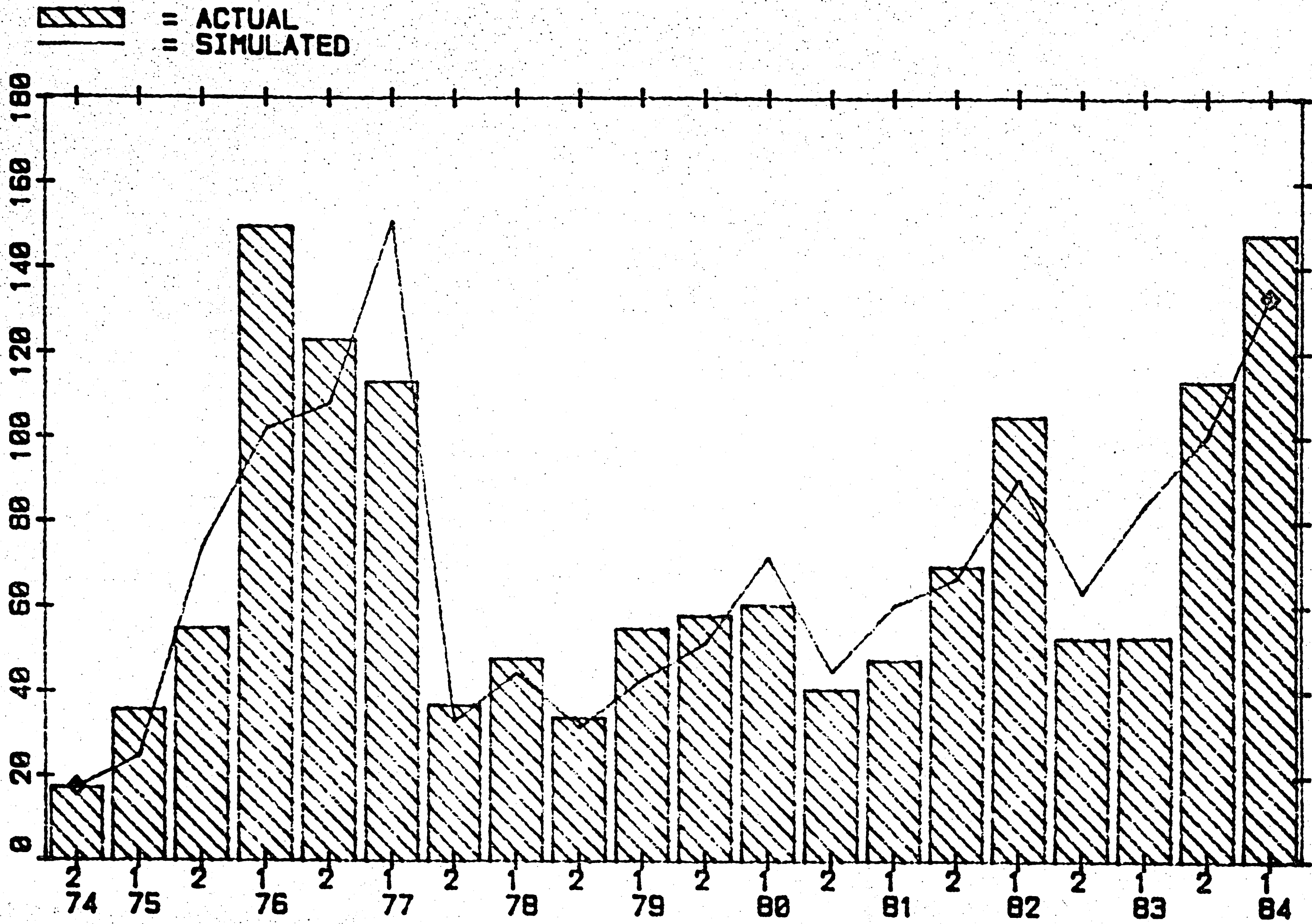
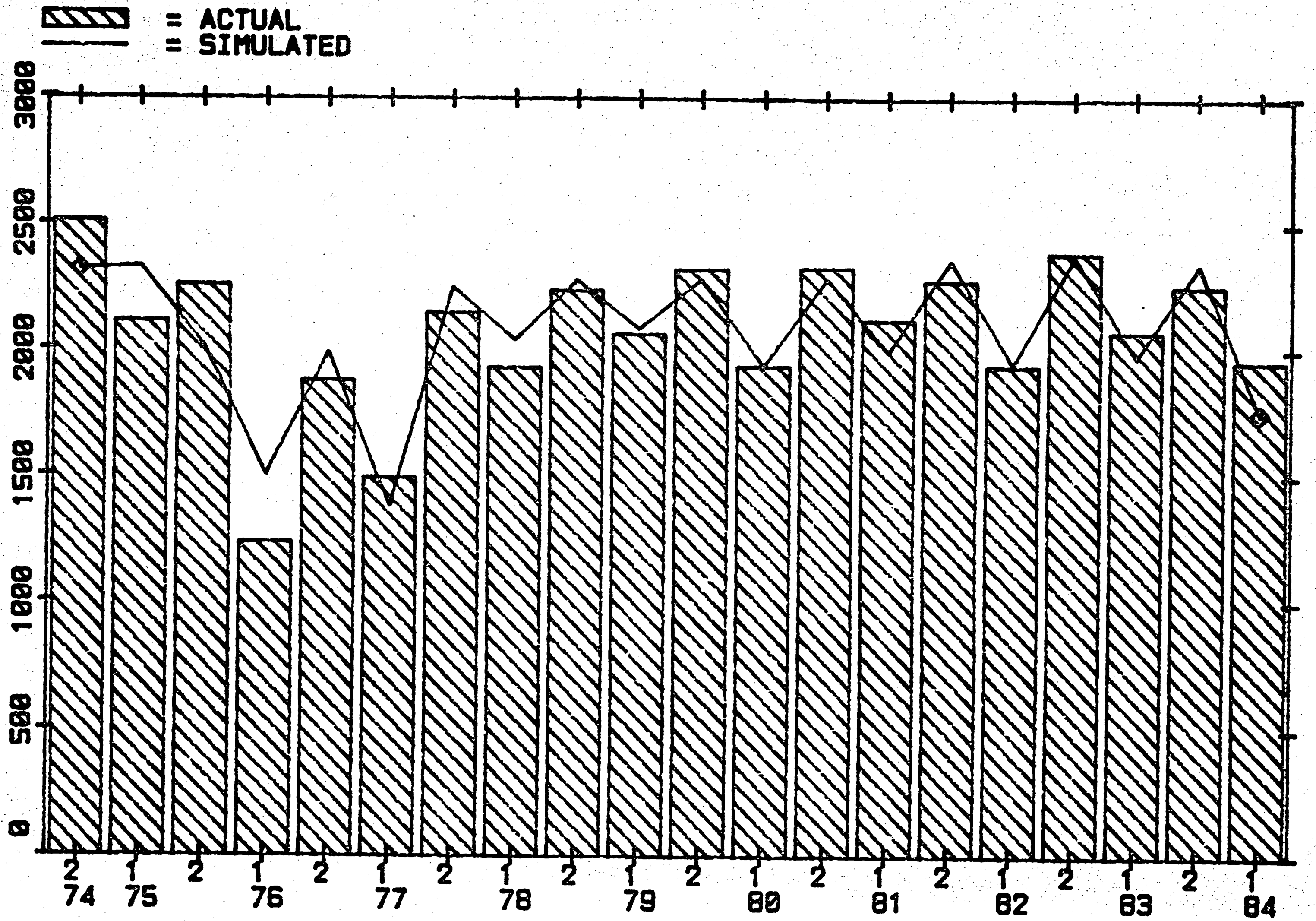


Fig 2.2 MOVEMENT INTO HUMAN CONS.



Appendix 2.2

POTATO AREA EQUATION

```
POTAREA  =  0.2584  +  0.4293*TAAREA  +  0.355*POTAREA.1
           (0.02)     (2.92)             (2.22)

                    +  2.149*POTRET.1/WHEATRET.1
                      (3.33)
```

```
R BAR Squared = 0.909
F Test (3,7)  = 34.5
D.h           = 1.06
d.f.          = 7
D.V. Mean     = 136
```

POTATO YIELD EQUATION

```
POTYIELD  =  3.12  +  0.504*TIME$A  +  10.65*EWSUN$JUN
            (0.30)   (5.73)           (3.37)

                   -  0.867*EWSUN$JUN2  -  9.924*TEMPRAIN$JUL
                     (3.77)                (4.55)

                   -  12.22*TEMPRAIN$AUG
                     (5.12)
```

```
R BAR Squared = 0.941
F Test (5.9)  = 45.7
D.W.          = 2.38
d.f.          = 9
D.V. Mean     = 31.2
```

MOVEMENT INTO HUMAN CONSUMPTION EQUATION

$$
\begin{aligned}
POTMOVE = {} & \underset{(51.7)}{7.24} + (\underset{(2.89)}{0.091} + \underset{(3.76)}{0.0934}*DUMDEC.1)*POTPROD \\
& - \underset{(2.01)}{0.3168}*BOARDOP + \underset{(3.61)}{0.0146}*TIME\$SA \\
& - \underset{(5.32)}{1.094}*DUMDEC.1*(POTMOVE.1/POTPROD)
\end{aligned}
$$

R BAR Squared = 0.854
F Test (5,17) = 26.7
D.W. = 2.27
d.f. = 17
D.V. Mean = 7.64

MAIN CROP POTATO PRICE

$$
\begin{aligned}
Ln(POTPR) = {} & \underset{(10.66)}{27.72} + \underset{(6.89)}{0.726}*Ln(RPI) - \underset{(11.02)}{3.273}*Ln(POTPROD) \\
& - \underset{(3.09)}{0.264}*DUMDEC
\end{aligned}
$$

R BAR Squared = 0.897
F Test (3,19) = 65.0
D.W. = 2.37
d.f. = 19
D.V. Mean = 3.99

EARLY POTATO AREA EQUATION

$$
EPAREA = \underset{(7.41)}{344.4} + \underset{(2.37)}{0.819}*EPAREA.1 + \underset{(3.45)}{2.95}*EPYIELD.1*EPRICE.1/(RPI\$A.1)
$$

R BAR Squared = 0.451
F Test (2,9) = 5.51
D.W. = 1.85
d.f. = 9
D.V.Mean = 41.75

EARLY POTATO YIELD EQUATION

EPYIELD = 7.53 + 0.366*POTYIELD
(2.59) (4.14)

R BAR Squared = 0.518
F Test (1,14) = 17.1
D.W. = 2.951
d.f. = 14
D.V. Mean = 19.43

EARLY POTATO MOVEMENT INTO HUMAN CONSUMPTION EQUATION

EPMOVE = 344.4 + 159.4*EPPRICE.1/POTPR2.1 + 8.64*TIME$A
(7.42) (2.37) (3.45)

R BAR Squared = 0.659
F Test (2,8) = 10.7
D.W. = 1.59
d.f. = 8
D.V. Mean = 541

EARLY POTATO PRICE EQUATION

EPPRICE = 4.772 + 0.164*TIME$A - 0.819*EPPRICE.1/POTPR2.1
(18.38) (10.04) (4.89)

- 0.0024*EPYIELD*EPAREA
(6.33)

R BAR Squared = 0.917
F Test (3,7) = 37.8
D.W. = 1.73
d.f. = 7
D.V.Mean = 4.13

NI POTATO AREA EQUATION

```
NIAREA  =  9.333  +  0.202*NIAREA.1
          (3.53)    (1.12)

                  +  0.514*NIPRICE.1*NIYIELD.1/WHEATRET.1
                    (3.01)
```

R BAR Squared = 0.420
F Test (2,11) = 5.72
D.W. = 1.726
d.f. = 11
D.V.Mean = 14.3

NI YIELD OF POTATOES

```
NIYIELD  =  16.51  +  0.354*TIME$A  +  4.473*POTYIELD
          (10.78)   (5.79)            (2.46)
```

R BAR Squared = 0.851
F Test (2,12) = 40.8
D.W. = 2.55
d.f. = 12
D.V.Mean = 24.0

NI POTATO PRICE

```
Ln(NIPRICE)  =  0.779  +  0.829*Ln(POTPR$A)
               (2.06)    (8.89)
```

R BAR Squared = 0.887
F Test (1,9) = 79.1
D.W. = 2.80
d.f. = 9
D.V. Mean = 4.12

NI MOVEMENT INTO HUMAN CONSUMPTION

```
NIMOVE  =  -18.53  +  0.0973*NIAREA*NIYIELD  +  0.522*NIAREA.1*NIYIELD.1
          (0.45)    (1.12)                     (5.79)
```

R BAR Squared = 0.727
F Test (2,11) = 18.36
D.W. = 1.89
d.f. = 11
D.V. Mean = 195

<u>Definition of variables</u>

POTAREA = Area of potatoes, June census.

TAAREA = Target area for potatoes.

POTPR = Semi annual potato price index.

POTPR$A = Average annual potato price index.

POTPR2 = Price index of potatoes for the second period of the calendar year, defined as an annual variable.

WHEATRET = Index of wheat returns per hectare.

POTYIELD = Annual potato yield per hectare.

TIME$A = Annual time trend.

EWSUN$JUN = Average daily sunshine in June.

TEMPRAIN$JUL = Ratio of average daily temperature to rainfall in July.

TEMPRAIN$AUG = As above, for August.

POTMOVE = Movement of potatoes into human consumption, on a semi-annual basis.

DUMDEC = Seasonal dummy, =1 in second period of calendar year.

POTPROD = POTAREA*POTYIELD , defined on a semi-annual basis, and hence taking the same value in both halves of the harvest year

BOARDOP = quantity of potatoes withdrawn from the market under PMB market operations.

RPI = Semi-annual retail price index.

EPAREA = Area of early potatoes.

EPYIELD = Yield of early potatoes

EPRICE = Price of early potatoes.

RPI$A = Annual retail price index.

EPMOVE = Movement of early potatoes into human consumption.

NIAREA = NI area of potatoes.

NIPRICE = NI annual price index for potatoes

NIYIELD = NI annual potato yield per hectare.

NIMOVE = Movement into human consumption of NI potatoes.

Chapter 3

A MODEL OF THE UK HORTICULTURAL SECTOR

(M.P. Burton & J.P. Martin)

Introduction

This Chapter outlines the Horticultural model that has been developed to provide forecasts of the value of horticultural output. It consists of 5 sections:

3.1) An outline of the horticultural sector in the U.K., and its relative importance.

3.2) A description of the Multi-Nomial Logit (MNL) model used in the land allocation model.

3.3) The estimated model, which uses a 33 crop classification of horticulture. The parameter estimates are reported for the area equations, and also for the equations determining output sold and price of each of the commodities. The system is completed by a number of accounting equations that accomodate any residual elements, and which also aggregate the revenue generated at the crop level up to the Horticulture level.

3.4) A truncated model is presented, which uses the top levels of the full model only. This determines the area of Orchard Fruit, Soft Fruit, Vegetables and Protected Vegetables. Equations are also estimated for returns per hectare for each of these four aggregates, allowing total revenue to be determined.

3.5) The performance of the two models in simulating horticultural revenue is compared.

3.1) HORTICULTURE IN THE U.K.

The definition of horticulture used in the Annual Review covers vegetables, fruit and non-edible crops but it excludes potatoes and hops. The diversity of crops contained in these classifications is large. For fruit, one can identify 24 different crops from the publication 'Horticultural Statistics', although a number of these are different varieties of cooking and dessert apple. At a more aggregate level, it comprises Orchard Fruit (cooking and dessert apples, pears, cider apples and perry pears, plums and cherries) and Soft Fruit (strawberries, raspberries, blackcurrents and 'others').

The vegetable sector consists of two groups: field crops and protected crops. Again, there are a large number of different crops, with some 20 grown in the open and 4 protected crops. Basic Horticulture Statistics identifies an equally wide range of non-edible crops (21 types), although revenue figures are given for aggregates (flowers in the open, flower bulbs, hardy nursery and protected crops). This brief review indicates the range of products labelled under horticulture; from extensive field crops to those grown under glass, from the multiple cropping systems of lettuce to the perennial crops.

In terms of the 1986 Annual Review's Table 22, horticulture is not an inconsiderable element. Table 3.1 gives some of the basic data for 1984, and indicates that horticulture generates some 11% of final output, and, in terms of output, is a little over 50% of the size of total cereals. The largest single element within horticulture, vegetables, also compares favourably with other activities, being 82% of the size of barley, and being larger than fat sheep and lambs, and poultry, and eggs. In terms of agricultural area it is not so significant, reflecting the high returns per hectare obtained in Horticulture. Thus, in 1984, total horticulture accounted for only 1% of total agricultural area, but 11% of total output.

Table 3.1

OUTPUT (Revenue) for selected crops, 1984

	£m	Hort. as a %	Veg as a %
HORTICULTURE	1252	1	0.62
VEGETABLES	778	-	1.00
TOTAL CEREALS	2424	0.52	0.32
WHEAT	1447	0.86	0.54
BARLEY	947	1.32	0.82
POULTRY	674	1.86	1.15
EGGS	554	2.26	1.40
MILK	2338	0.54	0.33
FAT CATTLE	1938	0.65	0.40
FAT SHEEP & LAMBS	557	2.25	1.40
FINAL OUTPUT	11650	0.11	0.07

Source: Annual Review, 1986

AREA for selected crops 1984

	"000 ha		Hort as a %
HORTICULTURE		218	1.00
VEGETABLES	148		-
ORCHARDS	39		-
SOFT FRUIT	16		-
UNDER GLASS	2		-
NON-EDIBLE	12		-
TOTAL CEREALS		4036	0.05
WHEAT		1939	0.11
BARLEY		1978	0.11
TOTAL AREA		17501	0.01

Source: June Census, 1984

3.2) THE THEORETICAL MODEL

The model used to determine the areas of particular crops is Theil's Multi-nomial Logit extension of the linear logit model. The method has been successfully used by Bewley, Colman and Young (forthcoming) to allocate cereal areas, and by Bewley and Young (forthcoming) to determine meat expenditures. The following outline of the model is drawn from these works, and the interested reader is referred to those papers for a more extensive discussion of the modelling technique. The implicit assumption of the model is that the decision process is a two (or more) stage procedure, whereby a pre-determined area is allocated between a number of competing uses.

Let TA be the total area to be allocated, and A_i the area of a particular crop, then the share allocated to crop i (W_i) is given by

$$W_i = A_i / TA \qquad 1)$$

and it is hypothesised that

$$W_i = \frac{e^{f_i + u_i}}{\Sigma_{j=1}^{n} e^{f_j + u_j}} \qquad 2)$$

where n is the number of activities. The functions f_j are then specified as functions of whatever economic or other factors that may determine the allocation of area to a particular crop. The advantage of this specification is that the shares are bounded by 0 and 1, and are constrained to add up to 1, (both for estimation and simulation). The disadvantage of the method is that, if share equations are estimated directly, there are cross equation covariances in the error terms which would require an appropriate estimation procedure. In order to avoid this a transformation is undertaken.

$$\text{Let} \quad Ln(\tilde{W}) = \frac{1}{n} . \Sigma_{j=1}^{n} Ln(W_i) \qquad 3)$$

$$\text{Then,} \quad Ln(W_i / \tilde{W}) = f_i - \bar{f} + u_j - \bar{u} \qquad 4)$$

$$\text{where} \quad \bar{f} = \frac{1}{n} \Sigma_{j=1}^{n} f_j \quad \text{and} \quad \bar{u} = \frac{1}{n} \Sigma_{j=1}^{n} u_j$$

So, if f_i is defined as being a function of (normalised) returns per hectare, i.e.

$$f_i = a_0 + \Sigma_{j=1}^{n-1} a_j . Ln(RET_{jt-1} / RET_{nt-1}) + u_i \qquad 5)$$

the transformed model becomes

$$Ln(W_i / \tilde{W}) = \partial_0 + \Sigma_{j=1}^{n=1} \partial_j . Ln(RET_{jt-1} / RET_{nt-1}) + v_i \qquad 6)$$

where the parameters are now defined as deviations from their mean values, and v_i is independent between equations.

To this basic model one can add whatever refinements one requires. For example, weather or indices of relative costs may affect the areas planted to each crop. One option that has been utilized in the model is the possibility that the shares will vary with the total area planted. Thus, equation 6) becomes

$$Ln(W_i/\tilde{W}) = a_0 + \Sigma_{j=1}^{n-1} a_j.Ln(RET_{jt-1}/RET_{nt-1}) + b_i.Ln\ (TA) + v_i \qquad 7)$$

The effect of this is that as the total area expands, the allocation of the area moves in the favour of a particular crop.

The other modification to the basic model that has been used is the introduction of dynamics into the specification. One method is to introduce <u>constrained</u> dynamics. Equation 6) would then become

$$Ln(W_i/\tilde{W}) = a_0 + \Sigma_{j=1}^{n-1} a_j.Ln(RET_{jt-1}/RET_{nt-1}) + g.Ln(W_i/\tilde{W})_{t-1} + v_i \qquad 8)$$

This is a constrained specification, because the coefficient on the lagged dependent variable (g), has to be constrained to be equal across all equations (see Bewley, Colman and Young).

If an unconstrained specification of the dynamics is used then n-1 lagged dependents are included in each equation. (One has to be excluded in order to avoid perfect correlation between the regressors, as the sum of the n normalised shares is unity). Equation 6) then becomes

$$Ln(W_i/\tilde{W}) = a_0 + \Sigma_{j=1}^{n-1} a_j.Ln(RET_{jt-1}/RET_{nt-1}) + \Sigma_{j=1}^{n-1} g_j.Ln(W_i/\tilde{W})_{t-1} + v_i \qquad 9)$$

This gives us six possible combinations of dynamics and explanatory variables. These can be represented as follows

	No Dynamics	Constrained Dynamics	Unconstrained Dynamics
No Total Area			
With Total Area			

3.3) AN APPLICATION TO THE HORTICULTURAL SECTOR

Given the large number of commodities identified within the overall grouping 'Horticulture' it is not possible to estimate the model as one unit. Instead, a recursive structure is established. Table 3.2 gives the crop groupings that have been used in the estimation of the model. It should be noted that some aggregation has taken place (in particular in the apple and pear groups) and that some minor crops have been excluded. The model operates in a number of stages. Thus, at the first stage, Horticultural area (area 60) is allocated between 4 alternative uses, Orchard (50), Soft Fruit (42), Vegetables (51), and Protected Vegetables (47). One can then allocate these sub-areas further, for example Orchard is split into Hard Orchard (40) and Soft Orchard (41), taking the area of Orchard Fruit as exogenous.

In this way one can move down to the crop level, giving 11 Multi-nomial Logit models. It should be noted that the non-edible sector (52) has been excluded from the analysis, as the data is not available in a form that is compatible with the other crops.

Each of the 11 models has been estimated, using each of the six specifications noted above. However, it has not been possible to aggregate all 11 models into a single model for simulation purposes, because the size of the resulting model exceeds the present limit of the program (PRODUCE) being used.

Table 3.2

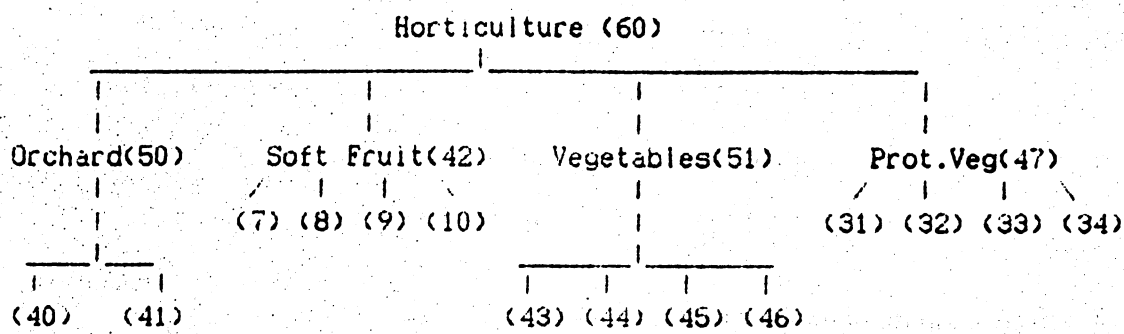
Crop Groupings

1 Dessert Apples	40 Hard Orchard	50 Orchard	60 HORTICULTURE
2 Cooking Apples			
3 Pears			
4 Cider Apples and Pears			
5 Plums	41 Soft Orchard		
6 Cherries			
7 Strawberries		42 Soft Fruit	
8 Raspberries			
9 Blackcurrants			
10 Others			
11 Beetroot	43 Roots	51 Vegetables	
12 Carrots			
13 Parsnips			
14 Turnips			
15 Onions, dry			
16 Onions, green			
17 Brussels	44 Brassicas		
18 Cabbage			
19 Cauliflower			
21 Broad Beans	45 Legumes		
22 Runner Beans			
23 Peas (marketed)			
24 Peas (processed)			
25 Asparagus	46 Others		
26 Celery			
27 Leeks			
28 Lettuce			
29 Rhubarb			
30 Watercress			
31 Tomatoes		47 Protected Vegetables	
32 Cucumbers			
33 Lettuce			
34 Mushrooms			
35 Flowers & Bulbs	52 Non-Edibles		
36 Nursery			
37 Protected Crops			

Efforts are being made to extend this limit to allow the full model to be run, but for the moment we have had to operate with a reduced model by excluding some of the lower levels. Thus in the discussion that follows, the "full" model refers to a system of 5 sub-models. Diagramatically this appears as:

Figure 3.1

The "Full" Model



The next problem is the selection of the preferred specification from the six estimated for each model. One criterion is to use a log likelihood test, but an alternative is to look at the simulation performance of the model, as it is the dynamic properties that will be important in any forecasts. The first two columns of Table 3.3 give the U2 statistics for the dynamic simulations for two alternative forms of the model. Note that this is a full simulation, with the areas generated at the first level feeding down to the second. The "Max. L.L." form uses the best logit model based on the log likelihood test, and the specification used is shown at the foot of the table. Although these results look quite acceptable (given that returns are being held exogenous) the model has some undesirable properties. It was found, for some lower level sub-models, that by relaxing some of the restrictions that were accepted by the log likelihood tests the simulation performance (as measured by the U(2) statistics) improved. Moreover, it was also discovered that the top level model was dynamically unstable (i.e. if returns were held constant at their 1982 levels, all of the horticultural area was allocated to 'soft fruit' by the year 2000). As this behaviour was thought to be unsatisfactory, additional specifications of the top level model were tried. The selection criterion adopted was lexiographic, based on long run stability, and then minimization of the within period U(2) statistic. The 'best' top level model found used constrained dynamics, and an additional normalised returns variable (that of the Orchard fruit), lagged two periods. This latter variable was chosen because of the possible need to allow a different adjustment path in the Orchard sector. This model is termed the 'stable form' model and the U(2) values associated with it are also given in Table 3.3 below.

Table 3.3

U2 Statistics, Dynamic Simulations 1965 to 1982

AREA, EXOGENOUS RETURNS

	Max L.L. Form	Stable Form	Final Form
HORTICULTURE			
Orchard	0.8327	1.3807	0.4776
Soft Fruit	0.2735	0.2810	0.3501
Vegetables	0.2019	0.2949	0.0291
Prot. Veg.	0.5735	0.6741	0.6447
Orchard			
Hard Orchard	0.8984	1.4548	0.5746
Soft Orchard	0.6144	0.9744	0.3199
Soft Fruit			
Strawberries	0.5513	0.5228	0.6150
Raspberries	0.6679	0.6217	0.5056
Blackcurrants	0.6692	0.8602	0.6707
Others	0.7889	0.6283	0.7660
Vegetables			
Roots	0.4333	0.5010	0.4087
Brassicas	1.0799	0.9158	0.7967
Legumes	0.6255	0.6251	0.6233
Others	0.8868	0.9146	0.8707
Protected Veg.			
Tomatoes	0.8143	0.7044	0.7849
Cucumbers	0.5969	0.6848	0.6609
Lettuce	0.5468	0.6357	0.6426
Mushrooms	0.6826	0.6512	0.7571

Maximum Log Likelihood Model

HORTICULTURE	unconstrained dynamics, with area
ORCHARD	unconstrained dynamics, without area
SOFT FRUIT	unconstrained dynamics, without area
VEGETABLES	constrained dynamics, without area
PROT. VEG.	unconstrained dynamics, with area

Table 3.3 cont.

Stable Model

HORTICULTURE	constrained dynamics, with area and an additional lagged return variable
ORCHARD	unconstrained dynamics, without area
SOFT FRUIT	unconstrained dynamics, with area
VEGETABLES	unconstrained dynamics, with area
PROT. VEG.	unconstrained dynamics, with area

Final Form Model

HORTICULTURE	MNL model. Redefined, excluding Orchard area unconstrained dynamics with area
	OLS model. For Total Orchard area only.
ORCHARD	unconstrained dynamics, without area
SOFT FRUIT	unconstrained dynamics, with area
VEGETABLES	unconstrained dynamics, with area
PROT. VEG.	unconstrained dynamics, with area

It is clear from a comparison of these two sets of results that the imposition of stability on the model has resulted in a substantial loss of within period performance, with the Orchard sector being most affected. In an effort to overcome this it was decided to remove the Orchard sector from the top level model, and use a simple ad-hoc OLS equation for it instead. The Orchard sub-model was retained, to allocate the total between the Hard and Soft Orchards.

Thus the only change to the model is that 'Horticulture' (Area 60 in Table 2 above) is now defined as the sum of Soft Fruit, Vegetables and Protected Vegetables (A42 + A51 + A47). The model structure can be represented as:

Figure 3.2

The "Adjusted" Full Model

```
                                     Horticulture (60)
                         ________________|________________
                         |               |               |
                         |               |               |
Orchard(50)        Soft Fruit(42)    Vegetables(51)    Prot.Veg(47)
     |              /  |  |  \           |             /   |    |    \
     |            (7) (8) (9) (10)       |          (31) (32) (33) (34)
  ___|___                           _____|_____
  |     |                           |   |   |   |
(40)  (41)                        (43) (44) (45) (46)
```

The estimation results of this new specification (for the period 1965 to 1982) are reported in Appendix 3.1, and the simulation results are given in the third column of Table 3.3, under the heading of the "Final Form Model". It will be noted that the performance has been improved, not only for the Orchard sectors, but in most of the others also. It is this final specification which will be used when the returns are made endogenous, and it is to this that we now turn.

Specification of the Returns per Hectare Equations

For most crops, the modeling of the returns per hectare was done in several stages. The price equations were estimated in double log form, and generally had the following structure.

$$Ln(P_i) = r_1 + r_2.Ln(TPDI) + r_3.Ln(A_i.Y_i) \qquad 10)$$

where TPDI is Total Personal Disposable Income and Y the crops gross yield (i.e. the total available for harvest, rather than the quantity actually harvested. This avoids the complication of the price and net yield being simultaniously determined).

For some crops it was thought that the output of competing crops may affect the price, and so the relevant variables were included also.

A feature of the Horticultural sector is that in some years all of the output that is available for sale is not sold, due to poor quality or a glut of produce. It was therefore decided that an output harvested equation should be estimated, of the form

$$Ln(OH_i/(A_i.Y_i)) = o_1 + o_2Ln(Y_i) \qquad 11)$$

where OH is the output harvested, and the dependant variable is the proportion of gross output ($A_i.Y_i$) that is harvested. The most significant determinant of this is the yield level, so that in years of high yield the proportion of gross output harvested is low. For some crops the yield was not significant, and in those cases the mean of the dependent variable is used.

Using equations 10 and 11 above as an example, the log of returns per hectare can now be determined as

$$Ln(P_i.OH_i/A_i) = r_1 + r_2.Ln(TPDI) + r_3.Ln(A_i.Y_i) + o_1 + (1+o_2).Ln(Y_i) \qquad 12)$$

For some crops, this procedure was not possible. This is because some crops are aggregates of a number of diverse sub crops (for example, 'others'(46) in the vegetable sector), and so one cannot define an aggregate quantity produced. In those cases, the returns per hectare were estimated directly. It is not clear cut as to which explanatory variables should be used in such an equation but the preliminary investigation suggested that the following specification worked quite well.

$$Ln(RET_i) = r_1 + r_2.Ln(TPDI) + r_3.W + \Sigma_{j=1}^{k} r_{4j}.Y_{ij} \qquad 13)$$

where W represents the weather variables relevant for a particular sector, and Y_{ij} is the yields of a subset of the crops that make up the sub sector i. The equations estimated for each crop or aggregate group are reported in Appendix 3.2.

It is intended that there should be further development of the returns sector of the model. If the model can be extended to the full 33 crop specification the problems caused by using aggregate sub sectors will be overcome. Until that is possible, it is thought that the aggregate returns (e.g. for brassicas) may be constructed as weighted average of the lower level returns, where the weights used are the average areas of the crops, rather than the actual areas which should be used (and which cannot be because the model does not disaagregate down to that level). On a more general level, it is intended to expand the price equations, so that the impact of other factors, such as imports, can be included.

It will be noted that no attempt has been made to explain the yields of the individual crops, so that in the simulations reported below they are treated as exogenous variables. The reason for this is that it is thought that the major determinant of yields is the weather, and therefore, if the model is to be used for forecasts of future developments in the horticultural sector, then average weather would have to be used, and therefore average yields generated. The only case were this is not true is if there is a trend in the yield, when it may be necessary to estimate a full yield equation in order to be able to accurately extrapolate the trend of the yield. This is only the case with protected vegetables, and yield equations for those crops will be developed if time permits.

Simulation with Endogenous Returns

Having estimated the returns equations for the lowest level crops it is then possible to simulate the full model, with returns endogenously determined. It should be noted that the higher level returns per hectare (needed in the top level sub-model) are also generated within the model, and consist of weighted averages of the relevant lower level returns, where the weights used are the areas to each of the lower level crops. The U(2) statistics are given in Table 3.4 below in the first two columns. As is to be expected, the results are not as good as when the returns are exogenous, but are still very acceptable.

In order to close the model it is only left to determine the total area in Horticulture, as up to now this has been taken as exogenous, and the model simply allocates this area between the different activities. Two possibilities have been considered within the context of the Manchester Model. The first is to construct a further MNL model that would allocate some higher area (for example, cultivated land) between competing activities (e.g. cereals, rape etc), one of which would be Horticulture. However, given the problems associated with the higher level model within horticulture, it was thought more prudent to take an ad-hoc approach and specify a single equation that determines the horticultural area. The estimated equation is given in Appendix 3.1, but the general form of the equation is to use a lagged dependent, lagged returns to horticulture deflated by an index of labour costs, and lagged returns to wheat deflated by an index of fertilizer costs. The inclusion of this equation into the system means that the exogenous variables needed to run the model are relatively few. Most of these are outside the bounds of what one may describe as the Horticultural sector, but some may be determined in other sub models within the overall Manchester Model. The full list of exogenous variables contains weather variables, yields of some Horticultural crops, Wage and Fertilizer price indices, Wheat price index and Wheat yields and Total Personal Disposable Income.

The U(2) statistics for this complete system are also given in Table 3.4. These are also very acceptable, and for only one crop (vegetables) do the U(2) statistics show a marked increase over those generated when the total area is exogenous. The performance of the total area equation is also good, given that the returns to total horticulture are generated within the model at a much lower level, and then aggregated up.

4) THE TRUNCATED MODEL

The model we have been dealing with so far is fairly large, with some 60 equations, and that is without the accounting equations needed to generate total revenue (see section 3.5). It was thought that this may be too large for inclusion in the full Manchester Model, and so a 'Truncated' model has been developed. It is envisaged that this reduced model will be used in general simulation runs, but that the full model may be used if there is a particular interest in the Horticultural sector.

The Truncated model is simply the top levels of the full model i.e. the total area equation, the allocation of that area between Soft Fruit, Vegetables and Protected Vegetables, and the equation for Orchard area. What is now needed are equations for the returns per hectare for the four aggregate commodities. A similar approach to that used to derive the 'aggregate crop' return equations in the Full model has been used. It is a fairly eclectic approach, with the emphasis on achieving a good fit rather than consistency between equations. The equations are in double log form, with TPDI capturing the general increase in nominal returns. Other explanatory equations include the yields of important crops that make up the aggregate, the aggregate's land area, weather variables and (for the protected vegetables) the level of Tomato imports. Detailed results are given in Appendix 3.3.

Table 3.4

U2 Statistics, Dynamic Simulations 1965 to 1982

FINAL FORM MODEL, ENDOGENOUS RETURNS

	A60 Exogenous		A60 Endogenous	
	AREA	RETURNS	AREA	RETURNS
TOTAL AREA				
Horticulture	--	--	0.7654	0.4022
HORTICULTURE				
Orchard	0.5477	0.6618	0.5477	0.6618
Soft Fruit	1.0297	0.6397	0.9047	0.6368
Vegetables	0.0802	0.5092	0.7848	0.5066
Prot. Veg.	0.6063	0.6986	0.7709	0.6265
Orchard				
Hard Orchard	0.6337	0.6878	0.6337	0.6878
Soft Orchard	0.3516	0.5616	0.3516	0.5616
Soft Fruit				
Strawberries	1.1742	0.7478	1.0543	0.7478
Raspberries	0.9211	0.4874	0.9563	0.4874
Blackcurrants	0.6340	0.8268	0.6236	0.8511
Others	0.6488	0.6268	0.9161	0.6381
Vegetables				
Roots	0.4291	0.5983	0.7928	0.5983
Brassicas	0.9029	0.6332	0.9091	0.5942
Legumes	0.6788	0.5898	1.0021	0.5898
Others	1.1193	0.5251	1.1614	0.5251
Protected Veg.				
Tomatoes	1.0402	0.5741	1.0543	0.5741
Cucumbers	0.9234	0.5654	0.9563	0.5654
Lettuce	0.7705	0.7460	0.6236	0.7460
Mushrooms	0.9525	0.7067	0.9161	0.7016

The resulting model is relatively small, with 18 equations. The simulation results generated by the truncated model are given in Table 3.5 and the relevant values for the Full model are repeated. The comparison brings up some interesting points. In the truncated model, the returns generally have the smaller U(2) statistics, implying that the aggregate returns equations are better than the aggregation of individual return equations. However, this advantage in the returns is not translated into a similar result in the area simulations, where the Full model is better for 3 out of the 5 sectors. These differences are not large, however, and it appears one loses little at the aggregate level by using the truncated model. One obviously loses the detail of what is happening within the aggregates.

Table 3.5

COMPARISON OF RESULTS FROM THE TRUNCATED MODEL AND THE FULL MODEL

U(2) Statistics. Dynamic Simulations 1965 to 1982

	TRUNCATED MODEL		:	FULL MODEL	
	AREA	RETURNS	:	AREA	RETURNS
Horticulture	0.8092	0.3420	:	0.7654	0.4022
Orchard	0.5466	0.5915	:	0.5477	0.6618
Soft Fruit	0.8834	0.5535	:	0.9047	0.6368
Vegetables	0.8331	0.4631	:	0.7848	0.5066
Prot. Veg.	0.8722	0.4378	:	0.7709	0.6265

3.5) SIMULATION OF VALUES

So far the model has been dealing with the area and returns to the various sectors. What is needed for the current model are estimates of the value of output for horticulture. To generate these is fairly straight forward, as we have returns per hectare and the area of each crop. The product of these will give us the value for a particular crop, and thus by aggregation, for a particular sub-sector and for horticulture as a whole. However, some accounting adjustments have to be made. Firstly, value is needed in Calendar years, while we have to date been operating with Harvest years, which run from approximately June to May. This is not a great problem as the harvest period for many crops lies within a single calender year, i.e. the 1978/9 harvest year for Runner Beans falls completely within 1978. However for some, (notably in the vegetable sector) the calender year contains sales from two harvest years. This was dealt with in the following way. For the four groups Orchard (50) Soft Fruit (42) Vegetables (51) and Protected Vegetables (47) the value of output in calender years was calculated from

Basic Horticultural Statistics. This was then regressed against the value of output for the two harvest years that fall within that calender year. This procedure effectively allocates the revenue generated in a harvest year between the two calender years that it falls in. In fact, it was only for Vegetables that any significant effect was found, with a suprisingly high proportion of the value of the Harvest year falling in the new year. There was no effect for the Orchard sector, which is surprising given the seasonal pattern of output, but that effect could not be found in the revenue figures.

Secondly, some elements of the sector have been excluded from the analysis, notably the non-edibles, but also some minor crops within both fruit and vegetables. These were incorporated on a simple % basis. Thus, the values generated by aggregating the calendar values for the crops identifed in Table 3.2 were compared with the reported values in the Output, Input and Net Farm Income table of the Annual Review. This was done for two sub groups, All Vegetables, (47 and 51 in table 2 above) and All Fruit (50 and 47). There was no time trend evident in the relationship, and so a simple % mark up was used, of 17% for All Vegetables, and 9% for All Fruit. This simply means that the value of All Vegetables reported in the Annual Review is on average some 17% higher than the value of the vegetables (both protected and field) included in Table 3.2.

A similar method was used to incorporate the non-edibles into the model. The value of non-edibles was expressed as a % of the value of Vegetables Plus Fruit (as reported in the Annual Review). This had an average of value of approximately 23%, but also showed a significant upward trend over the period, which was included.

With these accounting equations included, it is now possible to simulate the model, and generate an estimate of the 'Horticultural Value', as defined in the Annual Review. This has been done for the period 1976 to 1982, for both the Full model and the Truncated model, and the results are reported in Table 3.6 below. Percentage errors are reported in brackets. It is interesting to note that on the basis of the Root Mean Squared Error the truncated model is better. This may reflect the fact that the returns are more important in determining value, rather than area. However, using either model, the size of the errors are acceptably small, especially for a dynamic simulation over a 7 year period.

Conclusions

This chapter has reported the development of an econometric model of the U.K. Horticulture sector, a sector that has not previously been analysed in this way. The model has encompassed the area planted to particular crops as well as the prices received for the products, and the output harvested. The primary purpose of the model has been to generate the value of horticultural output, for use in the model of U.K. agriculture currently under development at Manchester. When used for this purpose it is likely that the "Truncated" form of the model would be implemented, but if a wider analysis of changes in the sector is needed then the full model, with its greater disaggregation, could be used. In particular, if the price equations are extended to include the influence of imports, then the model would provide a usefull vehicle for exploring the implications of Spanish and Portugese entry into the EEC on U.K. Horticulture.

Table 3.6

Simulations of Values. Dynamic Simulation 1976 to 1982

VEGETABLE VALUES £m CALENDAR YEARS

	ACTUAL	TRUNCATED	FULL
1976	405.1	418.2 (3.2)	425.1 (4.9)
1977	486.4	456.3 (-6.2)	448.7 (-7.7)
1978	460.4	459.6 (0.2)	447.7 (-2.7)
1979	536.4	524.4 (-2.2)	510.3 (-4.9)
1980	560.3	576.0 (2.8)	575.6 (2.7)
1981	583.5	585.7 (0.4)	595.9 (2.1)
1982	595.8	629.6 (4.8)	637.8 (6.9)

FRUIT VALUES £m CALENDAR YEARS

	ACTUAL	TRUNCATED	FULL
1976	115.9	118.1 (1.9)	121.5 (4.9)
1977	144.6	128.9 (-10.)	118.9 (-18.)
1978	152.5	163.6 (7.3)	153.7 (0.1)
1979	157.6	153.6 (-2.5)	166.4 (4.8)
1980	169.7	182.5 (7.5)	179.8 (5.3)
1981	187.2	188.5 (0.7)	199.3 (5.8)
1982	212.1	220.6 (-4.0)	208.8 (-2.5)

HORTICULTURE VALUES £m CALENDAR YEARS

	ACTUAL	TRUNCATED	FULL
1976	629.4	647.4 (2.8)	659.8 (4.9)
1977	755.1	710.3 (-5.9)	689.1 (-9.3)
1978	749.7	760.8 (1.5)	734.1 (-2.3)
1979	854.2	832.2 (-2.6)	830.5 (-2.9)
1980	912.9	936.1 (2.5)	932.3 (1.9)
1981	962.5	960.7 (0.2)	986.8 (2.3)
1982	1012.4	1054.6 (4.9)	1056.4 (4.0)
		RMS ERROR 27.4	RMS ERROR 35.3

APPENDIX 3.1

Parameter Estimates

Parameter estimates generated by the MNL model are difficult to interpret, as they are in mean deviation form, and therefore a parameter that is insignificant from zero does not imply that the variable should be excluded, but that the variable has an equal effect across all equations. This Appendix reports the results for each of the five sub models. In order to simplify the presentation, some conventions of notation should be noted. Individual crops are identified by their number in Table 2. LWWn refers to the log of the normalised share for crop n. The presence of .1 implies a one year lag. LNRETnx denotes the log of the ratio of returns to crops n and x. LNAn is the log of the area n. 't' statistics are not reported for the MNL model as they give little information about the importance of a variable in a particular regression. All equations have been estimated over the period 1964 to 1982, using annual data.

Area Model Parameter estimates

Total Horticulture Area

(t stats. in parentheses)

```
A60  =  80470  +  0.553 A60.1  +  639624 RET60.1/WAGE.1
        (2.41)    (4.11)          (2.73)

                -  6028 WHEATRET.2/FERTP.2
                  (2.91)
```

```
R BAR SQRD.    = 0.724
F TEST         = 15.8
D.h.           = -1.24
d.f.           = 14
```

Horticulture sub model

	Dependent Variable		
	LWW51	LWW42	LWW47
Intercept	-4.60	7.018	-2.41
LWW42.1	0.193	0.581	-0.773
LWW51.1	0.744	0.149	-0.893
LNRET5142.1	0.132	-0.145	0.0134
LNRET4742.1	-0.0427	0.0754	-0.0327
LNA60	0.441	-0.632	-0.191

<u>Total Orchard area</u>
(t stats. in parentheses)

$$A50 = \underset{(2.61)}{42514} + \underset{(1.89)}{0.404}\ A50.1 + \underset{(1.61)}{39322}\ RET50.1/WAGE.1 - \underset{(2.72)}{903}\ TIME$$

R BAR SQRD.	= 0.988
F TEST	= 480
D.h.	= 3.53
d.f.	= 14

<u>Orchard sub model</u>

	Dependent Variable	
	LWW40	LWW41
Intercept	2.11	-2.11
LWW40.1	0.647	-0.647
LNRET4041.1	0.0112	-0.0112
LNA50	-0.166	0.166

<u>Soft Fruit sub model</u>

	Dependent Variable			
	LWW7	LWW8	LWW9	LWW10
Intercept	0.178	-2.08	-0.257	2.16
LWW7.1	0.288	0.726	-0.289	-0.725
LWW8.1	-0.00347	0.490	0.153	-0.639
LWW9.1	-0.269	-0.109	0.562	-0.184
LNRET87.1	0.0153	0.0107	-0.0584	0.0324
LNRET97.1	0.0278	-0.0583	-0.0309	0.0614
LNRET107.1	-0.0514	-0.0662	0.0946	0.0229
LNA42	0.0258	0.161	0.0466	-0.233

Vegetable sub model

	Dependent Variable			
	LWW43	LWW44	LWW45	LWW46
Intercept	-3.60	0.961	-1.35	3.99
LWW43.1	0.735	0.022	-0.127	-0.631
LWW44.1	0.264	0.948	-0.555	-0.657
LWW45.1	0.303	0.247	0.441	-0.991
LNRET4344.1	0.335	-0.168	-0.0944	-0.0725
LNRET4544.1	-0.060	0.0671	0.0329	-0.040
LNRET4644.1	-0.0685	-0.057	-0.00491	0.130
LNA51	0.269	-0.0823	0.168	-0.355

Protected Vegetable sub model

	Dependent Variable			
	LWW31	LWW32	LWW33	LWW34
Intercept	1.69	6.59	-5.54	-2.74
LWW31.1	1.25	0.193	-0.823	-0.624
LWW32.1	0.229	0.587	-0.214	-0.602
LWW33.1	0.331	0.786	-0.0758	-1.04
LNRET3132.1	0.242	0.040	-0.174	-0.108
LNRET3332.1	-0.0967	0.085	0.146	-0.134
LNRET3432.1	-0.207	-0.0721	0.00264	0.276
LNA47	-0.234	-0.948	0.85653	0.326

APPENDIX 3.2

This Appendix reports the estimated equations for the returns per Hectare, either directly, or through separate price and output harvested equations. A list of variable names is in Appendix 3.4, but one general point will be made here. The Output Harvested equations are estimated with the dependent variable defined as the log of the ratio of output harvested to gross output (e.g. LNOH%7). At times this ratio is very constant over time, which is why the apparent fit is so poor. In fact for most crops the determination of Output Harvested is quite high.

Returns Equations

Strawberries

$$LNP7 = \underset{(15.4)}{2.22} + \underset{(25.9)}{0.894}\ \ln(TPDIH)$$

R BAR SQRD	= 0.974
F TEST	= 674
D.W.	= 1.44
d.f.	= 17

LNOH%7 = -6.97

mean value used

Raspberries

$$LNP8 = \underset{(9.59)}{1.81} + \underset{(20.8)}{0.941}\ \ln(TPDIH)$$

R BAR SQRD	= 0.959
F TEST	= 431
D.W.	= 1.37
d.f.	= 17

LNOH%8 = -6.95

mean value used

Blackcurrants

$$LNP9 = \underset{(15.4)}{2.22} + \underset{(25.9)}{0.894} \ln(TPDIH)$$

R BAR SQRD = 0.974
F TEST = 674
D.W. = 1.44
d.f. = 17

$$LNOH\%9 = \underset{(102)}{-6.82} - \underset{(2.2)}{0.00173}\ SERAIN\$JUL$$

R BAR SQRD. = 0.18
F TEST = 4.94
D.W. = 2.14
d.f. = 17

Others

$$LNP10 = \underset{(1.86)}{5.5} + \underset{(12.1)}{0.874} \ln(TPDIH) - \underset{(1.39)}{0.4} \ln(A10.Y10)$$

R BAR SQRD = 0.952
F TEST = 178
D.W. = 1.12
d.f. = 16

$$LNOH\%10 = \underset{(107)}{-6.75} - \underset{(3.1)}{0.115} * \ln(Y10) + \underset{(3.72)}{0.00068}\ SERAIN\$JUL$$

R BAR SQRD. = 0.475
F TEST = 9.16
D.W. = 1.97
d.f. = 16

Tomatoes

$$LNP31 = \underset{(3.6)}{14.4} + \underset{(5.08)}{1.051} \ln(TPDIH) - \underset{(2.5)}{1.92} \ln(Y31) - \underset{(2.5)}{0.764} \ln(IM31)$$

R BAR SQRD = 0.958
F TEST = 139
D.W. = 1.21
d.f. = 15

$$LNOH\%7 = \underset{(119)}{-6.65} - \underset{(4.9)}{0.058} * \ln(Y31)$$

R BAR SQRD. = 0.57
F TEST = 24.9
D.W. = 2.76
d.f. = 17

<u>Blackcurrants</u>

$$\mathrm{LNP9} = \underset{(15.4)}{2.22} + \underset{(25.9)}{0.894} \ln(\mathrm{TPDIH})$$

R BAR SQRD = 0.974
F TEST = 674
D.W. = 1.44
d.f. = 17

$$\mathrm{LNOH\%9} = \underset{(102)}{-6.82} - \underset{(2.2)}{0.00173}\ \mathrm{SERAIN\$JUL}$$

R BAR SQRD. = 0.18
F TEST = 4.94
D.W. = 2.14
d.f. = 17

<u>Others</u>

$$\mathrm{LNP10} = \underset{(1.86)}{5.5} + \underset{(12.1)}{0.874} \ln(\mathrm{TPDIH}) - \underset{(1.39)}{0.4} \ln(\mathrm{A10.Y10})$$

R BAR SQRD = 0.952
F TEST = 178
D.W. = 1.12
d.f. = 16

$$\mathrm{LNOH\%10} = \underset{(107)}{-6.75} - \underset{(3.1)}{0.115} * \ln(\mathrm{Y10}) + \underset{(3.72)}{0.00068}\ \mathrm{SERAIN\$JUL}$$

R BAR SQRD. = 0.475
F TEST = 9.16
D.W. = 1.97
d.f. = 16

<u>Tomatoes</u>

$$\mathrm{LNP31} = \underset{(3.6)}{14.4} + \underset{(5.08)}{1.051} \ln(\mathrm{TPDIH}) - \underset{(2.5)}{1.92} \ln(\mathrm{Y31}) - \underset{(2.5)}{0.764} \ln(\mathrm{IM31})$$

R BAR SQRD = 0.958
F TEST = 139
D.W. = 1.21
d.f. = 15

$$\mathrm{LNOH\%7} = \underset{(119)}{-6.65} - \underset{(4.9)}{0.058} * \ln(\mathrm{Y31})$$

R BAR SQRD. = 0.57
F TEST = 24.9
D.W. = 2.76
d.f. = 17

Hard Orchard

```
LNRET40  = -2.46 + 0.798 ln(TPDIH) - 0.179 ln(MRAIN$AUG)
           (3.69)  (10.9)            (1.52)

                 + 0.01048 MMINT$MAY
                   (0.23)
```

```
R BAR SQRD.  = 0.927
F TEST       = 77.5
D.W.         = 1.46
d.f.         = 15
```

Soft Orchard

```
LNRET41  = -3.66 + 0.796 ln(TPDIH) - 0.269 ln(MRAIN$JUN/MSUN$JUN)
           (10.7)  (9.58)            (2.78)

                 - 0.348 LN(MRAIN$AUG/MSUN$AUG)
                   (2.37)
```

```
R BAR SQRD.  = 0.863
F TEST       = 38.9
D.W.         = 1.23
d.f.         = 15
```

Roots

```
LNRET43  = -3.45 + 0.880 ln(TPDIH) - 0.141 ln(EARAIN$JUN/EASUN$JUN)
           (19.6)  (20.9)            (3.30)
```

```
R BAR SQRD.  = 0.962
F TEST       = 231
D.W.         = 1.49
d.f.         = 16
```

Brassicas

```
LNRET44  = 11.5  + 0.762 ln(TPDIH) - 0.103 ln(EARAIN$JUN/EASUN$JUN)
           (2.14)  (13.9)            (3.01)

                 - 0.01048 ln(A44)
                   (2.79)
```

```
R BAR SQRD.  = 0.976
F TEST       = 243
D.W.         = 2.04
d.f.         = 15
```

Legumes

LNRET45 -3.43 + 0.638 ln(TPDIH)
(26.6) (20.7)

R BAR SQRD. = 0.959
F TEST = 4285
D.W. = 2.38
d.f. = 17

Others

LNRET46 = -2.69 + 0.862 ln(TPDIH) - 0.123 ln(EARAIN$JUN/EASUN$JUN)
(15.3) (20.6) (2.90)

R BAR SQRD. = 0.961
F TEST = 222
D.W. = 1.97
d.f. = 16

APPENDIX 3.3

Estimates of the aggregate returns per Hectare equations used in the "Truncated" model

Orchard

LNRET50 = -2.60 + 0.802 ln(TPDIH) - 0.337 ln(MRAIN$AUG)
(5.39) (17.6) (3.07)

+ 0.165 ln(MRAIN$JUN)
(2.41)

R BAR SQRD. = 0.949
F TEST = 113
D.W. = 1.42
d.f. = 15

Soft Fruit

LNRET42 = 7.01 + 0.768 ln(TPDIH) - 0.727 ln(Y7) - 0.597 ln(Y8)
(1.57) (18.5) (3.73) (2.78)

- 1.22 ln(A42)
(2.75)

R BAR SQRD. = 0.982
F TEST = 240
D.W. = 2.30
d.f. = 14

Vegetables

LNRET51 = -3.34 + 0.798 ln(TPDIH) - 0.084 ln(EARAIN$JUN/EASUN$JUN)
(30.2) (30.3) (3.15)

R BAR SQRD. = 0.981
F TEST = 474
D.W. = 1.73
d.f. = 16

Protected Vegetables

LNRET47 = 4.30 + 0.693ln(TPDIH) - 0.196 ln(MSUN$AUG) - 0.597ln(IM31)
(4.10) (37.3) (2.54) (3.29)

R BAR SQRD. = 0.988
F TEST = 493
D.W. = 1.55
d.f. = 15

APPENDIX 3.4

Variable Definitions

Individual Crops, or Aggregates of Crops are identified by the number given in Table 2.

Many of the variable names follow a particular classification scheme. Thus

An	Denotes the area of crop n.
LNAn	Denotes the Log of area n.
LNWWn	Denotes the normalised share of crop n within its immediate grouping.
Yn	Denotes the Yield per Hectare of crop n.
RETn	Denotes the Returns per Hectare to crop n.
LNRETnx	Denotes the log of the ratio of Returns per Hectare to crops n and x.
LNPn	Denotes the log of Price per tonne of crop n.
OHn	Denotes the Harvested Output of crop n.
LNOH%n	Denotes the log of the ratio of Harvested Output to Gross Output for crop n
TPDIH	Total Personal Disposable Income, in Harvest Years.
SERAIN$JUL	Rainfall in the South East in July, as a % of Monthly Average.
MRAIN$AUG	Rainfall in the Midlands in August, as a % of Monthly Average
MRAIN$JUN	Rainfall in the Midlands in June, as a % of Monthly Average
MSUN$JUN	Hours of Sunlight in the Midlands in June, as a % of Monthly Average
MSUN$AUG	Hours of Sunlight in the Midlands in August, as a % of Monthly Average
EASUN$JUN	Hours of Sunlight in East Anglia in June, as a % of Monthly Average
EARAIN$JUN	Rainfall in East Anglia in June, as a % of Monthly Average
MMINT$MAY	Minimum Air Temperature in the Midlands in May, Degrees Centigrade, constrained to equal zero if positive.
IM31	Imports of Tomatoes.

WHEATRET	Returns per Hectare to Wheat.
FERTP	Fertilizer Price Index.
WAGE	Wage index.
TIME	Time Trend.

Chapter 4

THE MILK AND BEEF MODEL

(M.P. Burton)

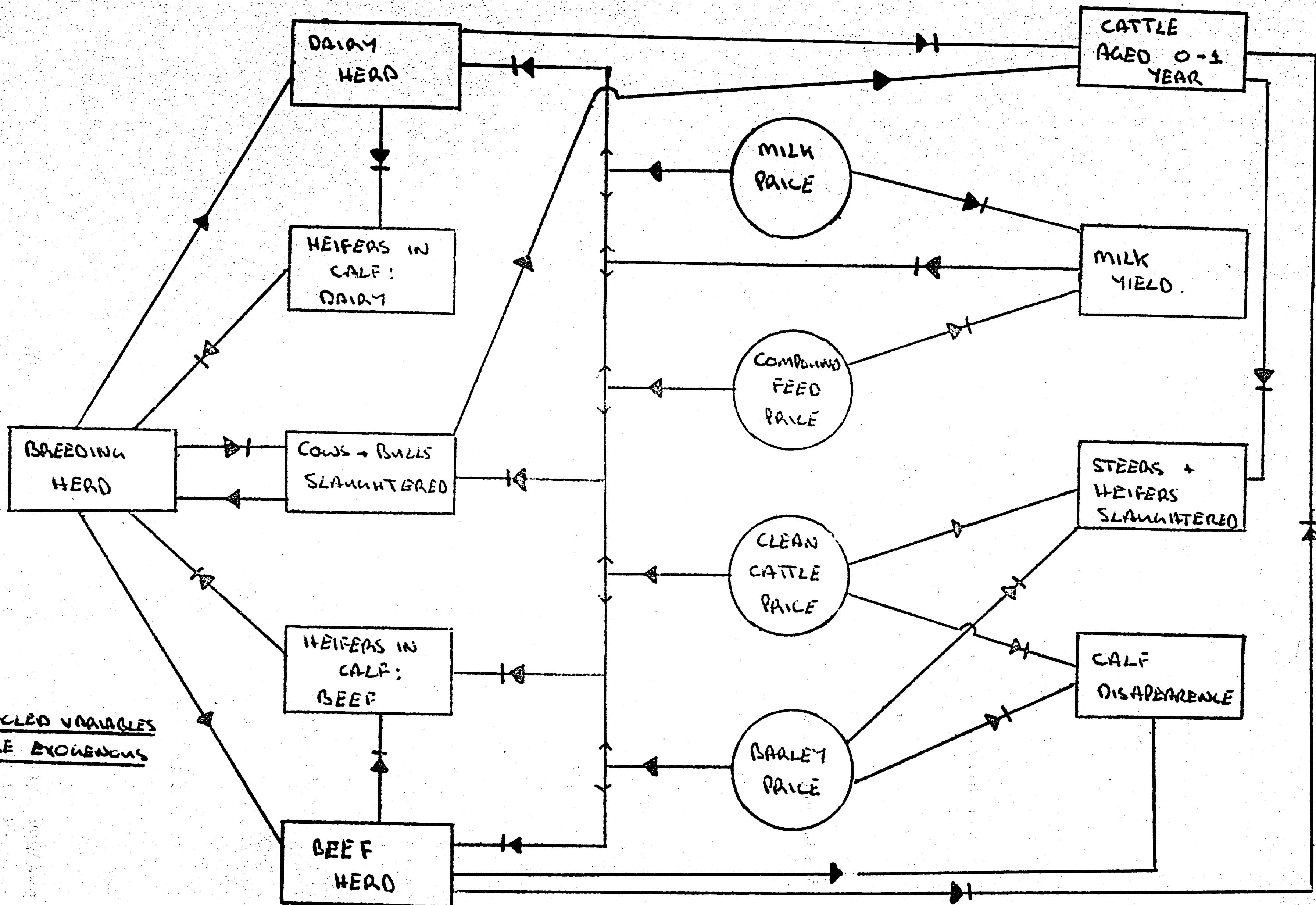
Introduction

The milk and beef sectors have been modelled together: because of the substitution possibilities between the two sectors; because of their joint contribution to beef production and because some of the data does not distinguish between cattle used for the two activities.

The major factor affecting the sectors has been the introduction of milk quotas in April 1984. This development has profound implications for modelling the sectors, to the extent where it may be considered inappropriate to try. In that case, the size of the dairy herd would have to be imposed upon the model over a range of values, and a series of simulations undertaken (for example, see Bingley et al 1985). The problem with this approach is that a change in the Dairy herd will have knock on effects onto other sectors, all of which will have to be incorporated in a consistent manner. Also, for any policy scenario, there will be several sets of results, leading to the possibility of information overload. Because of this it was thought desirable to formalize the determination of the dairy herd, even if the method of doing so has to be a little unconventional. The approach used will be explored later in this paper, but it is sufficient to say here that a set of equations are estimated over the pre- quota period for both animal stocks and flows, and these are than adapted for use in the post quota period.

The equations of the dairy and beef sector models have been estimated using semi annual data for the period 1964.2 to 1983.2. The flow diagram in Figure 4.1 gives a general overview of the inter-linkages between the animal stocks and flows. A general description of the equations is given in the next section, with detailed results in Appendix 4.1.

FIG. 4.1



N.B. CIRCLED VARIABLES ARE EXOGENOUS

Milk Yield Equation

The major feature of the milk yield over the period being studied is the strong upward. There are several methods of modelling this essentially technical development, but most will utilize a time trend of some form. The one that has been used here is to explain the annual, percentage increase in semi annual yields. This removes the seasonal variation in the level of yields. However, it also means that any variable that has a +ve (-ve) effect on the numerator, and hence the ratio, should have a +ve (-ve) effect on the denominator when lagged two periods, and hence a -ve (+ve) effect on the ratio as a whole. Thus, any variable used is included with a further two period lag.

The major weather influence that has been identified is that of a dry summer (represented by the ratio of sunshine to rainfall over a 3 month period) on milk production during the second half of the year. The same ratio for the months May and June is also significant for the first half of the year, although the term lagged two periods is not.

The lagged milk:feed price ratio is used to capture expectations about the profitability of increasing yields by feeding concentrates. The expected -ve effect of the ratio lagged a further 2 periods is present. The overall fit may not seem high, but this is an equation that uses % changes. The Durban Watson statistic is a marked improvement on alternative specifications.

Breeding Herd Equation

The breeding herd equation is based on the herd identity, i.e

$$BH_t = BH_{t-1} - OUTFLOW_{t/t-1} + INFLOW_{t/t-1}$$

It is estimated for the combined beef and dairy herds as the slaughterings data does not identify the source of the cull cows, the measure of outflow. The best indication of inflow into the herd currently available is the number of in calf heifers at the beginning of the period. The beef and dairy heifers are separately included to allow for a difference in the calving pattern between them. Variations in the seasonal pattern of calvings (or, more exactly, variations in the proportion of heifers in calf that calve in the following six months) was also allowed for, but was only significant in the case of the dairy heifers. The need for the dummy variable used arises from a particular data problem. In December 1973, the question referring to the number of in-calf heifers was excluded from the census. In order to accomodate this a dummy variable is used for the period. The dummy variable DUMBULLBEEF is used for the years 1980 to date to allow for the fact that there has been an increase in the quantity of bull beef that has been produced, and which distorts the cow and bull slaughterings data, which no longer represents culls from the breeding herd alone.

Dairy Herd Equation

The breeding herd has to be split into its two components: the dairy and beef herds. The method adopted is to use Theils Multi-Nomial Logit model, which is outlined in detail in Bewley et al, and has been used by Burton and Martin in the Horticulture model (reported in Chapter 3). The interested reader is referred to those papers for further information. The equation is estimated in a double log form, with the dependant variable defined as the log of the (normalised) share of the breeding herd used for milk production. The normalization used is fairly obscure, but it avoids cross equation co-variances between the error terms. The advantage of the method is that it ensures that the shares add up to unity, and are constrained to lie between zero and unity. The determinants are a lagged dependent variable, a seasonal dummy, milk returns deflated by the cattle compound fed price lagged 1 and 3 periods and the clean cattle price deflated by the feed barley price, again lagged 1 and 3 periods. These deflated returns are annual averages of the semi annual averages, as denoted by the $A at the end of the variables. The expected milk yield during the six month period ending at t is a simple niave extrapolation of the rate of change of the milk yield, i.e

$$EXPMY_t = MILKYIELD_{t-2} * MILKYIELD_{t-2} / MILKYIELD_{t-4}$$

Beef Herd equation

Because there are only two shares in the model, the beef herd dependent variable is simply the negative of that used in the dairy herd equation. The explanatory variables used are identical in both equations, and therefore, the parameters of the estimated equation are the negative of those in the dairy equation.

Cull Ratio Equation

The cull ratio is fundamentally a partial adjustment equation, with milk and cattle returns having the expected -ve effect on the culling decision. The price of fat cows was included in some specifications but was not found to be significant. The ratio of clean cattle prices was also significant, implying that there is a response to the rate of change of prices, and not just to the price levels. Some considerable effort was expended on trying to quantify an expected 'knock on' effect in culling, i.e. a reduction in culling this period should presumably lead to an increase in some future periods as the herd age increases. Lagged culling ratios and longer lags on the prices did not yield any significant results. The time trend implies a slight increase in the rate of culling, a feature which obviously cannot continue indefinitely, but which may be indicative of a change in the management techniques over the data period.

In-Calf Heifers Equation : Dairy

In previous studies, the modelling of the number of dairy in calf heifers has proved difficult (e.g. Burton 1982). If one believes that the Dairy replacement is fundamentally different from the run-of-the-mill store heifer then the numbers of replacement heifers is to some extent determined at the date of insemination of the mother with a beef or dairy bull. This means that there are substantial lags betweeen the decision and the observable outcome. The production of dairy heifers is seen as a long run investment decision relating to expected requirements in 2 or 3 years time, and the best proxy that has been found for those expectations is the change in the dairy herd around the time of insemination of the mother. Thus the annual change in the dairy herd lagged some 4 periods is used. It is interesting to note that this variable is not significant for any lags other than 4 or 5, wich gives some support to the arguments outlined above. As can be seen, the lagged dairy herd variable is not particularly significant; this may be caused by the relative constancy of the dairy herd over the period. However, it was retained in the specification to ensure that no inconsistency arises in the relationship between the size of the dairy herd and the number of replacements during simulations. As has been noted earlier, there is a missing observation in 1973$2, and a dummy variable is introduced for that period.

In-Calf Heifers Equation : Beef

The use of heifers for the beef herd is much less restricted and the specification indicates a much more flexible response. The equation has the expected signs on the milk and clean cattle returns variables. A dummy variable is introduced for December 1972, which saw a substantial increase in the number of heifers. This may have been in anticipation of entry into the EEC, (and the beef herd expanded substantially after this date) but no alternative specification using prices could capture this increase. The size of the beef herd at the beginning of the period is used to allow for the replacement of cull cows from the herd. The use of the beef herd lagged 3 periods is more problematic. It is included primarily for statistical reasons, as it substantially improves the fit of an equation that has proved difficult to model (it raise the R Bar Squared from 0.82 to 0.92), but it may be justified on the grounds that the use of replacements to increase the herd, combined with a cohort effect, may introduce a cyclical element into the demand for heifers.

Cattle One Year Old and Under

Because the data period is semi-annual, this equation has been structured on a net inflow basis. The number of cattle aged one or less will be equal to the number aged one or less the previous period, plus those calves born in the intervening six months, less those who were born between one year and one year six months before, and who are now aged one year to eighteen months. The first stage of modelling this procedure is to identify the potential number of calves that could be born in a six month period. This is defined as the sum of the beef and dairy herds at the beginning of the period, less the number of cows slaughtered in the following six months. It is thought unlikely that a cow that has been culled in that period would have had a calf, as it is the post calving period that is most productive in terms of milk. The estimated coefficient applied to this composite variable (defined as CALFHERD in Appendix 4.1) gives the proportion of cows that calf in the following six months. This proportion is allowed to change seasonally, and also over time through a simple time trend. The outflow will be the same function of CALFHERD, but lagged two periods. and with negative coefficients. Not all of the calves born will be recorded as cattle under one year, as they may be slaughtered or exported. A net calf disappearance variable is therefore introduced, again in difference form, as both the inflow and outflow elements have to be adjusted downwards. The coefficient is acceptably close to the expected value of unity.

Steer and Heifer Slaughterings Equation

The major deficiency with this equation is that the slaughterings needed for the model are for home reared cattle only, whereas the reported monthly statistics are for all slaughterings. Untill a reliable semi-annual series for imported fat stock is obtained this will remain a problem. The best response to this is to define a steer and heifers disapearence variable. This comprises the recorded slaughterings (aggregated from monthly data) plus exports (from Output and Utilization, split equally between the two halves of the year) less the estimate of imported fat stock that have been slaughtered, (derived on an annual basis as the difference between the annual total of all slaughterings and those recorded in Output and Utilization as home production, again split equally between the two halves of the year). This composite variable, although rough, has the advantage of corresponding with the quantity element that underlies the values reported in Table 22 of the Annula Review.

The main element driving the equation is the average number of cattle aged one or less, three periods before. This implies that the animals are being slaughtered at around the age of 24 months. An attempt was made to allow for any change in the age of slaughterings, but this was not significant. It would be expected that the clean cattle returns would also affect the slaughterings, as they would determine the relative profitability of feeding the animals further or of slaughtering them. The prices that were found significant were the annual changes in the clean cattle price, and the ratio of clean cattle price to feed barley price. All of these coefficients are -ve, whereas one would have thought that if (for example) a change in price had increased current slaughterings by inducing slaughterings earlier, there should have been an offsetting effect in later periods, but such an effect was not found.

Calf Disapearence Equation

The definition of this variable is also not completely satisfactory. Although a semi-annual series for slaughterings has been derived, the export element has been taken from Output and Utilization, and split equally between the two halves of the year. Because calf disapearence is a fairly small element with respect to the overall calvings, there was no significant relationship between the breeding herd size, or the number of cattle under the age of one. The clean cattle price ratio indicates that fewer calves are disposed of as the price rises, presumable as they can be profitably fed on. The negative effect of the annual change in the beef herd is as would be expected, with a down turn in the herd resulting in fewer calves being kept.

Value of Outputs

The final output that is required of the model is the values of milk and fat cattle. For fat cattle, this is fairly straight forward. For each half year, the quantity of meat produced is derived by multiplying the number of animals slaughtered by a dressed carcase weight conversion factor. The semi-annual price indices for clean cattle and fat cows have been converted into a money measure by comparing the indices with an average price for the first half of 1980. By multiplying the meat equivalent by the price index and aggregating over the two halves of the year, we generate an estimate of the value for a calender year. As it stands, this figure will not correspond exactly with the value given in Table 22. The main cause of this error will be the exclusion of the value of offal (which is included in the published figures), but may also be caused by other adjustments to the published figures (e.g. the subtraction of the marketing and transport costs), or inaccuracies in the calculation of the semi annual price index. This is allowed for by comparing the estimate of value generated by our method with that given for 1980 in Table 22, and deriving an adjustment factor. This ensures that the accounting is correct for 1980, but not necessarily for other years. In fact, the error in the other years is acceptably small, as can be seen in Table 4.1. A similar method was used to derive an accounting equation for the value of milk output. The milk output used is that sold off farm, so that the milk that is fed to stock or wasted on farm is already accounted for (in effect we are using net yield). The value is split into the two componants, milk for liquid consumption or manufacture off farm, and milk for manufacture on farm.

Table 4.1

Comparison of Actual Value with Accounting Value

	Cattle		Milk		Man. Milk	
	Actual	Acc.	Actual	Acc.	Actual	Acc.
1978	1258	1253	1591	1574	29	26
1979	1420	1407	1730	1706	34	30
1980	1499	1499	1925	1925	35	35
1981	1600	1592	2064	2056	37	38
1982	1666	1655	2341	2349	43	42
1983	1819	1820	2452	2465	40	39

MODEL SIMULATION

The model has been simulated within the estimation period, for the years 1965.1 to 1983.2. The prices have been maintained as exogenous so that one is simply dealing with the dynamic properties of the model and the interlinkages between the various components. The U(2) statistics are given in Table 4.2 below.

The prices that are exogenous to this system have been modelled, and are described in Chapter 9. Because of the specification of the prices, there is a substantial degree of interlinkage between the milk, beef, poultry and pig sectors. Therefore, even if prices are endogenous, a simulation of the beef and milk model in isolation would exclude some of the major feedbacks between sectors, and hence some major influences of the sector on its own prices. A full simulation of the sectors is given in Chapter 11, along with all other elements of the model, were the values of the outputs are determined.

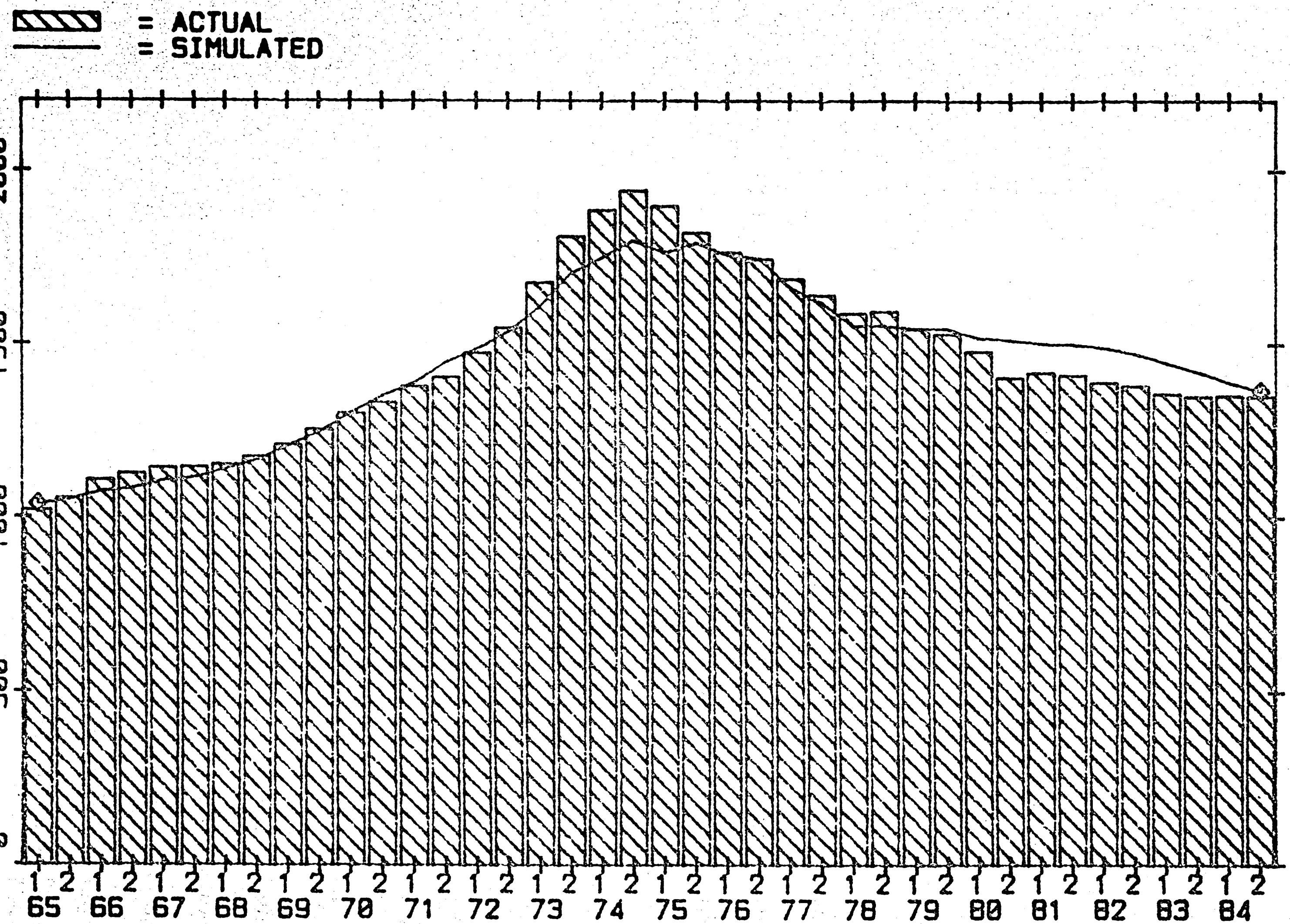
Table 4.2

Milk and Beef Sector Simulation Results.

Variable	U(2)
MILKYIELD	0.2187
BREEDHERD	0.8363
DAIRYHERD	0.7274
BEEFHERD	1.2268
CATTLE1	1.2930
SHDISP	0.6842
HEFINC$B	0.3247
HEFINC$D	0.1168
C$BDISP	0.5215
CALFDISP	0.6537

When interpreting the U(2) statistics of a system, one has to be careful not to attribute a poor performance to a single equation if it has a high U(2) value, as the problem may lie else where in the model. This appears to be the case for the beef herd. The errors that occur in the breeding herd seem to translate into larger errors for the beef sector than for the dairy sector. In fact the U(2) statistic gives something of a misleading picture, as the largest error for the beef herd is less than 10%, and most are substantially less. Also, the majority of the turning points are captured, as is seen in Figure 4.2. The cause of the problem seems to be a consistent under or overshooting of the actual value (i.e. serial correlation of the simulation error), a problem that can be traced back to the breeding herd simulation. The position for the dairy herd is much better, with a maximum error of around 3%. These errors have the greatest effect on CATTLE1, which is driven almost entirly by the herd numbers. However, given

Fig 4.2 BEEF HERD SIMULATION



that this is a dynamic simulation over 38 periods, these errors are perhaps not too great a cause for concern.

Forecasting Dairy Herd Numbers Under Quotas

The imposition of milk quotas means that yield and herd equations cannot be run, unconstrained, into the future. However, such equations contain much of the information about the way dairy farmers respond to the economic enviroment. The challenge posed by Quotas is to construct a system where estimated equations can be meaningfully used while imposing the quota constraint.

The method at present under development to achieve this is outlined below.

The estimated dairy herd equation is represented by

$$DAIRYHERD_t = f(EXPMY_t, X)$$

Were EXPMY is the expected yield during the period t-1/t, with the expectation made at time t-1. X represents all other variables in the system. Thus we are suggesting that the size of the dairy herd will be determined in part by the output the farmer expects from each cow. In the model we have estimated so far, this is a simple extrapolation of the change in milk yields, with milk yield themselves being generated within the model by the equation as reported above. However, under quotas, it is not possible to continue to use this system, as yields would continue to rise, as would the expected yield, and the resulting milk output may exceed the quota, with all the penalties that this would produce.

The alternative is to ensure that the herd size and the expected yield that will be produced are consistent with the Quota restriction. In order to do this, the estimated yield equation is not used for simulation over the post Quota period, and the expected yield is no longer a simple extrapolation. Instead one uses the milk output identity:-

$$MILKOUTPUT_t = MILKYIELD_t * (DAIRYHERD_t + DAIRYHERD_{t-1})/2$$

to derive the following expression for expected milk yield

$$EXPMY_t = \frac{MILKQUOTA_t * 2}{DAIRYHERD_t + DAIRYHERD_{t-1}}$$

with MILKQUOTA being the desired level of production in that 6 month period, and DAIRYHERD being determined by the estimated equation.

This expression is run simultaneously with the estimated herd equation. The justification for this is as follows. The number of cows kept is suggested to depend on the profitability of dairying, and this relationship will continue in the post quota period as it did before. However, under quotas, some compromise between cutting yields and cow numbers has to be found. Therefore, if yields are reduced, then so will cow numbers (because profitability will have fallen), and the farmer will aim to have a certain number of cows conditional on the yield he expects to produce, with both decisions being conditional on expecting to produce his quota. It is possible to solve ex-post for the actual yield produced by adjusting the expected yield by the weather effects that have been estimated in the yield equation.

A serious problem with the model is that it operates on a semi-annual basis, whereas the quota is set over an annual period. Thus farmers are not constrained to produce a limited output in any six month period, as long as the total over the milk year is less than the quota. The simplest method of solving this problem is to fix the seasonality of milk production at its 1983 levels, so that the value for MILKQUOTA in any six months will be equal to the % cut in production imposed by the annual quota, applied to the 1983 milk output in those six months.

The model has been solved for the three periods, December 1984 to December 1985. No attempt has been made to simulate the June 1984 decision. This is partially because the quota was imposed half way through the relevant six month period, and also because there was some evidence that farmers' response to the quota in those initial months was more directed by panic than by any economic rationality. It has been solved dynamically, in that the June 1985 figure uses the forecast value for December 1984, not the actual value.

Table 4.3

Simulation for the Post Quota period - Exogenous Seasonality

Dairy Herd	Dec. 1984	June 1985	Dec. 1985
Actual	3311	3130	3257
Simulated	3271	3217	3217
% error	-0.97	1.90	-1.20

These errors are fairly small, and give some encouragement for continuing the development of the model.

Endogenous seasonality

The constraint imposed upon the seasonality of milk supplies is restrictive, particularly with the recent changes in the seasonality of milk prices. If the seasonality of milk supplies is to be made endogenous then a decision about herd size and yield for the current period has to be made consistent with the expected levels of the herd and yield in the following period.

The fact that the quota and the model year do not coincide introduces some problems again. The assumption used is that farmers attempt to hit a 12 month rolling total quota level. The quota constraint is now imposed over a full year, so that

$$MILKQUOTA_t + MILKQUOTA_{t+1} = \frac{[DAIRYHERD_t + DAIRYHERD_{t-1}]*EXPMY_t}{2} + \frac{[DAIRYHERD_t + DAIRYHERD_{t+1}]*EXPMY_{t+1}}{2}$$

The relevant expressions for the herd size at t and t+1 are derived from the estimated equation . This gives 3 equations in the 4 unknowns, $DAIRYHERD_t$, $DAIRYHERD_{t+1}$, $EXPMY_t$, and $EXPMY_{t+1}$. The model is closed in the following way.

$$EXPMY_t = RAT * EXPMY_{t+1}$$

Were RAT is the ratio of the milkyield in period t to that in period t+1, as calculated from the yield equation (i.e. the ratio of milk yields that would have held if quotas had not been imposed). This means that the seasonality of milk production that would have occured without quotas is maintained in the post quota period.

We now have a system that

a) Maintains the relationship between seasonal yields with that which held before quotas

b) Determines herd size on the basis of expected yield, and desired future herd size and yield

c) Ensures that the yields and herd size are consistent with the milk supply required to meet the years quota.

This model has been simulated for the period 1984.2 to 1985.2, and the results are given in Table 4.4.

Table 4.4

Simulation for the Post Quota period - Endogenous Seasonality

Dairy Herd	Dec. 1984	June 1985	Dec. 1985
Actual	3311	3130	3257
Simulated	3302	3186	3199
% error	-0.27	1.80	-1.80

The problem with this specification is that it is substantially more difficult to run as part of a complete system, as the model has to solve for two periods simultaneously, and it does not improve the simulation to any great extent. Instead, it is suggested that this more complex technique be reserved for any analysis that is particularly interested in the seasonality of milk production.

DAIRY HERD RATIO

```
LWWDH    = 0.214 + (0.855 + 0.080*DUMDEC)*LWWDH.1
          (6.15)  (35.9)   (8.38)

                + 0.0776*( MILKP$A.1*EXPMY )
                  (3.58) (    COMPP$C$A.1   )

                - 0.0666*(   CCP$A.1    )
                  (2.76) (BARLEYP$A.1 )

                + 0.0616*( MILKP$A.3*EXPMY.2 )
                  (2.68) (    COMPP$C$A.3     )

                - 0.0588*(   CCP$A.3    )
                  (2.43) (BARLEYP$A.3 )
```

R BAR SQUARED = 0.983
F TEST = 315
D.H. = 1.37
D.F. = 31
D.V. MEAN = 0.419

CULL RATIO EQUATION

```
C$BSLGHT        = 0.151   - 0.0362*CCP$A.1/CCP$A.3 + 0.00957*DUMDEC
BREEDHERD.1      (7.69)    (2.39)                    (4.07)

                - 153.2*MILKP$A.1*EXPMY/COMPP$P$A.1*1000
                  (2.33)

                - 0.0351*CCP$A.1/BARLEYP$A.1 + 0.00205*TIME
                  (2.09)                       (7.02)
```

R BAR SQUARED = 0.639
F TEST = 14.4
D.W. = 1.85
D.F. = 33
D.V. MEAN = 0.0951

IN-CALF HEIFERS EQUATION : DAIRY

```
HEFINC$D = 302 +  0.196*(DAIRYHERD.4 - DAIRYHERD.6)
          (1.3)  (2.5)

            - 215*DUMDEC - 473*DUM73$2
              (20)         (16)

            + 0.115*DAIRYHERD.4
              (1.6)
```

R BAR SQUARED = 0.956
F TEST = 207
D.W. = 2.13
D.F. = 34
D.V.MEAN = 557

IN-CALF HEIFERS EQUATION : BEEF

```
HEFINC$B   = 1.59  -  314*DUM73$2 + 87.8*DUM72$2
            (0.0)  (13.8)         (3.76)

               +  127*CCP$A.1/BARLEYP$A.1
                  (2.5)

               -  648*MILK$A.1*EXPMY/COMPP$C$A.1
                 (3.1)

               +  0.536*BEEFHERD.1 - 0.364*BEEFHERD.3
                  (12.5)             (9.20)
```

R BAR SQUARED = 0.918
F TEST = 31
D.W. = 1.95
D.F. = 31
D.V. MEAN = 198

CATTLE ONE YEAR OLD AND UNDER

```
CATTLE1 - CATTLE1.1 = - 1.13*(CALFDISP - CALFDISP.2)
                         (7.99)

 + (0.187 + 0.0138*TIME - DUMDEC*(0.631 + 0.0287*TIME))*CALFHERD
   (1.26)  (4.24)                (2.95)   (6.27)

 - (0.187 + 0.0138*TIME.2 - DUMDEC*(0.631 + 0.0287*TIME.2))*CALFHERD.2
   (1.26)  (4.24)                  (2.95)   (6.27)
```

R BAR SQUARED = 0.787
F TEST = 29.9
D.H. = 2.74
D.F. = 34
D.V.MEAN = 3624

STEER AND HEIFER DISAPEARENCE EQUATION

```
SHDISP   = 1318  -  561*CCP/CCP.2   -  431*CCP.2/CCP.4
          (7.52)   (4.44)             (3.18)

                 -  346*CCP$A.2/BARLEYP$A.2
                   (3.41)

      +   (0.438 - 0.0094*DUMDEC.1)*(CATTLE1.4+CATTLE1.3)
          (7.52)   (11.01)                    2
```

R BAR SQUARED = 0.779
F TEST = 27.8 (5,33)
D.W. = 1.39
D.F. = 33
D.V. MEAN = 1461

CALF DISAPEARENCE EQUATION

```
CALFDISP = 455.6 + 63.7*DUMDEC - 289.3*CCP.1/BARLEYP.1
          (7.62)  (3.95)        (4.36)

                 - 0.401*(BEEFHERD-BEEFHERD.2)
                  (4.69)
```

R BAR SQUARED = 0.595
F TEST = 19.6
D.W. = 0.846
D.F. = 35
D.V.MEAN = 220

VARIABLE DEFINITIONS

DAIRYHERD	= Cows in Milk + Cows in Calf not in Milk, Mainly for Milk Production
BEEFHERD	= Cows in Milk + Cows in calf not in Milk, Mainly for Beef Production
BREEDHERD	= DAIRYHERD + BEEFHERD
DAIRYRATIO	= DAIRYHERD/BEEFHERD
HEFINC$D	= Heifers in Calf, Intended for Milk Production
HEFINC$B	= Heifers in Calf, Intended for Beef Production
HEFRATIO$B	= HEFINC$B/BEEFHERD.1
CBSLGHT$A	= Cows and Bulls Slaughtered, adjusted for 53 week Statistical Years
CULLR$C	= CBSLGHT$A/BREEDHERD.1
CATTLE1	= Cattle Less than One Year Old
SHDISP	= Steers and Heifers Slaughtered from home production, plus exports, adjusted for 53 week statistical years.
BARLEYP	= Barley Price index
BARLEYP$A	= (BARLEYP + BARLEYP.1)/2
CCP	= Clean Cattle Price Index
CCP$A	= (CCP +CCP.1)/2
MILKP	= Milk Price Index
MILKP$A	= (MILKP + MILKP.1)/2
COMPP$C	= Compound Feed Price Index : Cattle
COMPPCA	= (COMPP$C + COMPP$C.1)/2
TIME	= Time Trend
DUMDEC	= Dummy Variable, = 1 in Second Period, 0 in First
DUM73$2	= Dummy Variable, = 1 in Second Period 1973, 0 Otherwise
DUM72$2	= Dummy Variable, = 1 in Second Period 1972, 0 otherwise
SUN:RAIN$JJA	= Ratio of average sunshine in June July and August to average rainfall in that period, expressed as deviation from mean.
SUN:RAIN$MJ	= As above, for the months May and June.

Chapter 5

THE SHEEP SECTOR

(M Burton)

Introduction

There have been several models of the UK sheep sector developed (see, for example, Lavercombe (1978) and Phimister (1985) for a review) and the model reported in this section follows the groundwork laid down in those earlier reports. In particular, the model developed by Phimister (1985) has been taken as a starting point, and some minor developments made to it. The sheep sector can be split into three distinct elements: the pure bred upland sheep, which are self-sufficient in their production of replacements, but which provide male store lambs for fattening, and draft ewes for the upland flocks. The upland flocks produce first cross lambs which provide the replacements for the lowland flock, and again, male lambs for slaughter. Ideally one would want to model each sector separately, as the economic conditions that effect each will differ (in particular the available alternative activities) and the flocks have followed differing time paths over the past 30 years. However, attempts to dissaggragate down to this level have usually resulted in severe data problems being encountered; in particular, the identification of the different flocks sizes, and the flows of sheep between them. The alternative is to model the whole flock as a single unit, and accept the specification error bias that may result. The central feature of the model is the flock identity i.e.

$$BREEDEWES_t = BREEDEWES_{t-1} + SHEARLINGS_t - DISSAP_{t/t-1}$$

The inflow and outflow elements of this are then determined within separate equations. The production of lamb and mutton is then derived from the key livestock numbers thus generated. In the following sections a general description is given of each element of the model, and more detailed results are given in the appendix. A point to note is that most of the model has had to use annual data, for the period 1962 to 1982, but where possible semi-annual data has been used.

Shearlings Equation

There is no direct measure of the number of lambs that enter the breeding flock, but there are several indicators that can be used. Alternatives are the number of ewe lambs for breeding at December, and the number of shearlings at June in the following year. It would seem that the ewe numbers overstates inflow, but shearlings data understates it. It is realistic to assume that ewe lambs are not fully incorporated into the flock due to low expectations about their productivity in the first year. In the final model shearlings were taken as a proxy for inflow, primarily because the simulation results of the model incorporating them had a better simulation performance. The level of inflow is considered as an investment decision, based upon expected returns. However, in the empirical work, neither lamb prices nor other prices could be succesfully incorporated. What was significant was the yield of lambs per ewe. The dynamic structure of the model uses a double lag on both the yield variable and the lagged endogenous variable.

Disappearance Equation

Data is available on the slaughter of cull ewes and rams, but these figures do not correspond to the expected level of slaughterings given the change in flock size and the level of inflow implied by the number of ewe lambs or shearlings. The cause of this discrepancy could be errors in the definition of inflow or stocks, net exports or mortalities of sheep on farm, which are not recorded as slaughtered. In order to reconcile this, a disappearence variable was defined as

$$DISSAP_{t/t-1} = BREEDEWES_{t-1} + SHEARLINGS_t - BREEDEWES_t$$

and an equation devised to explain this variable. In this way the flock identity will still hold. One still has to deal with the number of sheep culled, as this will be the basis of the value of culled sheep. There has to be some relationship between the two, as DISSAP contains the culled sheep. The method of modelling this is to construct a variable defined as

$$CULLPER_{t/t-1} = SHCULLS_{t/t-1}/DISSAP_{t/t-1}$$

Where SHCULLS is the recorded culls in a calendar year. This ratio variable therefore represents the proportion of culled sheep in the total number that leave the flock. This ratio is a function of time, as one would expect an improvement in management over time, and the average winter temperature during the winter months, as one would expect that the harder the winter, the greater the number of casualties. There is also some form of dynamic interaction over time, as, if one has a particularly hard winter and removes the weaker stock, then in the next year one would expect to see fewer casualties amoung the total exits from the flock. The lagged dependent variable therefore should have a negative coefficient, which it has.

<u>Cull Equation</u>

The next aspect of the problem is to determine the number of sheep culled from the flock. As there is semi-annual data available on culls, this equation is modelled on this basis. A major determinant of the number of culls is the size of the flock at the beginning of the period, as the productive life of the ewe is finite. One would also expect to see some economic aspects also, as culling will be an important method of adjusting the flock size. The yield of lambs per ewe, for the most recent harvest year, was found to be significant, and with the expected negative sign. Here prices were also found to be important, with the lagged lamb price deflated by the clean cattle price having a significant and negative sign. The lamb price used is the return to the farmer, rather than the market price, as this includes any variable premium payments also.

It is then possible to determine the level of DISSAP with the following identity:

$$DISSAP_{t/t-1} = CULLS\$A_{t/t-1}/CULLPER_{t/t-1}$$

Lambs in June Equation.

Given the nature of lamb production, one can only determine the number of lambs produced using an annual equation, with the number recorded at the June census as a proxy for production. The dependent variable is defined as the number of lambs at June divided by the breeding flock in the previous December, which gives a measure of yield per ewe. There is an increase in yield over time, which follows a quadratic time trend. The Scottish temperature in February was also found to have the expected positive effect. Weather variables for other regions or months were not found to be significant.

Lamb Slaughterings Equation.

Data is available on the number of lambs slaughtered on a semi-annual basis, but they are best modelled using annual equations for each half year. The number of lambs slaughtered in the second half of the year is specified as a function of the number of lambs recorded in June. There is also some evidence of a trend away from slaughtering in the second period, possibly due to changes in the seasonal price structure, but no effect could be found explicitly. There are two weather effects also. The first, the temperature in spring, is a proxy for the ability of the farmer to finish lambs quickly, with a low temperature increasing slaughterings in the second period. The overall temperature for the year has a positive effect, possibly as a proxy for the need for less replacements as a result of lower casualties in better years, or possibly a higher survival rate of the lambs.

The number of lambs slaughtered in the first half of the year is a function of the net lambs remaining from the previous period (i.e. lambs in June less slaughterings in the second period of the previous year). Not all of the lambs slaughtered will be from the previous year as some early lambs will have been slaughtered from that year's crop. These are proxied by the size of the breeding flock at the begining of the year. The temperature in February has a positive effect, presumably as a measure of the weather induced mortality of lambs, and the ability to finish the lambs early.

Lamb and Mutton Production Equation

The quantity of mutton and lamb produced is available on a semi-annual basis. The main determinant is the slaughterings of lambs, with a time varying coefficient to allow for a declining carcass weight. The number of cull ewes should also be a factor, and a seasonal dummy is included, to allow for differing seasonal weights.

Market Lamb Price Equation

The (deflated) market lamb price is a function of the production of both lamb and mutton, with the expected negative effect on price. Imports of lamb also deflate the market price, while the price of competing meats, pigs and beef, has a positive impact on the lamb price, the latter both currently and with a lag. The problem of simultaneity between the price and slaughter decision has been investigated, but the presence of a buffer in the form of the variable premium system may mean that this is not a problem in that farmers decisions to sell will be based on institutional rather than market prices.

Lamb Returns Equation

In the production element of the model, farmers respond to net returns rather than market prices. It is therefore necessary to link the two in some way. The farmers return for lambs is defined as the market price plus a variable premium payable if the market price is less than the guaranteed price, but not if it is greater. The two prices are linked by a simple OLS regression. In simulation the problems become greater as it is nessarcary to calculate whether a premium is payable, and how much it should be. This is done by defining the premium as

```
LAMBVP  =  (0.5*ABS(LAMBSP-MKTLMP)/(LAMBSP-MKTLMP) +0.5)*(LAMBSP-MKTLMP)

      Where LAMBSP = Lamb support price.
            MKTLMP = Market lamb price.
               ABS = 'Absolute value'.
```

The first part of this expression generates a dummy variable equal to 1 if the market price is less than the support price and zero if it is greater.

Ewe Price Equation

Although not used within the behavioral elements of the model, the ewe price is needed to generate the value of mutton produced. The dependent variable is defined as the ratio of the ewe price to the lamb price. This has a strong seasonal element but is also affected by the slaughterings of lambs and ewes.

Value of Lamb and Mutton Equation

The value of lamb and mutton is defined from the slaughterings of lambs multiplied by the lamb price, summed over the two halves of the calendar year, plus the number of ewes slaughtered valued at the cull ewe price. This index of value is zeroed onto the reported 1980 value of sheep and mutton by a suitable multiplicative adjustment factor. A comparison of the actual and accounting values is given in Table 5.1 below.

Table 5.1

Comparison of Actual and Accounting Values for Lamb and Mutton

	ACTUAL	ACCOUNTING
1977	267.0	265.6
1978	299.5	296.9
1979	319.1	326.4
1980	405.2	405.2
1981	464.9	451.8
1982	515.1	529.5
1983	574.4	590.3

Simulation Results.

Theil U(2) statistics appear to be satisfactory, although the use of a combined annual and semi annual framework means that one cannot use the figures given for the annual variables. However, inspection of Table 5.2 below, which reports the statistics for the semi-annual variables over the period 1977 to 1983 indicates that the model is performing well. Also, the simulated estimates of the value are good, with only 2 periods having errors approaching 10%.

Table 5.2

Theil U(2) statistics

Lamb slaughter	0.120
Lamb and Mutton production	0.195
Market lamb price	0.271
Lamb variable premium	0.271
Lamb returns	0.233

Appendix 5.1

SHEARLINGS EQUATION

```
SHEARLINGS  =  -1469  +  0.441*SHEARLINGS.1  -  0.482*SHEARLINGS.2
               (3.25)    (2.55)                 (4.08)

                      +  2794*LAMBS$JUN/BREEDEWES$DEC.1
                         (6.59)

                      +  1186*LAMBS$JUN.1/BREEDEWES$DEC.2
                         (1.94)
```

R BAR Squared = 0.896
F Test (4,17) = 46.4
D.W. = 0.777
d.f. = 17
D.V. Mean = 2567

CULLS AS A % OF DISAPPEARENCE EQUATION

```
CULLPER  =  0.269  -  0.590*CULLPER.1  +  0.00899*GBTEMP$WINT
            (2.44)    (3.32)              (4.34)

                   +  0.00376*TIME$A
                      (3.42)
```

R BAR Squared = 0.590
F Test (3,18) = 11.1
D.W. = 0.188
d.f. = 18
D.V.Mean = 0.531

CULLS EQUATION

$$SHCULLS = \underset{(6.75)}{1416} + \underset{(7.29)}{0.104*BREEDEWES.1} + \underset{(8.43)}{0.123*BREEDEWES.2}$$

$$+ \underset{(2.47)}{1.54*GBTEMP\$FEB} - \underset{(7.51)}{696*LAMBP.1/CCP.1}$$

$$- \underset{(6.14)}{1480*LAMBS\$JUN/BREEDEWES\$DEC.1}$$

R BAR Squared = 0.826
F Test (5,40) = 43.7
D.W. = 1.50
d.f. = 40
D.V.Mean = 650

LAMB YIELD EQUATION

$$LAMBS\$JUN/BREEDEWES\$DEC.1 = \underset{(48.2)}{0.998} + \underset{(3.04)}{0.010*SCOTEMP\$FEB}$$

$$- \underset{(2.41)}{0.00702*TIME\$A} + \underset{(4.00)}{0.000453*TIME\$A^2}$$

R BAR Squared = 0.722
F Test (3,20) = 20.9
D.W. = 1.91
d.f. = 20
D.V. Mean = 1.04

SLAUGHTER OF LAMBS EQUATION: SECOND HALF OF YEAR

$$LAMBSLGHT2 = \underset{(3.13)}{-7271} - \underset{(1.74)}{165*EWTEMP\$MAY} - \underset{(5.09)}{74.0*TIME\$A} + \underset{(8.86)}{0.698LAMBS\$JUN}$$

$$+ \underset{(3.66)}{65.8*GBTEMP\$YR}$$

R BAR Squared = 0.785
F Test (4,19) = 22.0
D.W. = 1.38
d.f. = 19
D.V. Mean = 7018

SLAUGHTER OF LAMBS EQUATION: FIRST PERIOD OF YEAR

```
LAMBSLGHT1  =  -  293.9  +  0.249*BREEDEWES$DEC.1   +  114.3*EWTEMP$FEB
                 (0.41)    (3.79)                     (5.25)

                          0.104*(LAMBS$JUN.1-LAMBSLGHT2.1)
                         (1.96)
```

R BAR Squared = 0.716
F Test (3,20) = 20.3
D.W. = 2.06
d.f. = 20
D.V. Mean = 4145

PRODUCTION OF LAMB AND MUTTON EQUATION

```
LAMBPROD  =  6.556  +  (0.0201 - 0.0000534*TIME$SA)*LAMBSLGHT
            (2.15)     (35.42)   (7.17)

                    +  (0.0239 - 0.0112*DUMDEC)*SHCULLS
                       (5.78)    (4.91)
```

R BAR Squared = 0.995
F Test (4,41) = 2202
D.W. = 2.236
d.f. = 41
D.V. Mean = 123.1

MARKET LAMB PRICE EQUATION

```
MKTLMP/RPI  =  0.238  +  0.989*MKTCCP/RPI  +  0.813*MKTCCP.1/RPI.1
              (2.00)    (2.94)                (3.14)

                      +  0.495*PIGP/RPI  -  0.00284*LAMBPROD
                        (3.84)             (6.58)

                      -  0.000536*LAMBIMP
                        (1.98)
```

R BAR Squared = 0.896
F Test (5,23) = 49.1
D.W. = 1.81
d.f. = 23
D.V.Mean = 0.599

LAMB RETURNS EQUATION

$$LAMBP = \underset{(0.18)}{-0.228} + \underset{(69.32)}{0.645}*(MKTLMP + LAMBVP)$$

R BAR Squared = 0.994
F Test (1,26) = 4805
D.W. = 2.72
d.f. = 26
D.V.Mean = 76.3

EWE PRICE EQUATION

$$EWEP/MKTLMP = \underset{(8.52)}{0.913} + \underset{(4.35)}{0.0001}*LAMBSLGHT - \underset{(2.49)}{0.1495}*DUMDEC - \underset{(4.13)}{0.001}*SHCULLS$$

R BAR Squared = 0.413
F Test (3,24) = 7.34
D.W. = 1.21
d.f. = 24
D.V. Mean = 0.800

Definition of variables

SHEARLINGS = number of shearlings reported at June census.

LAMBS$JUN = Number of lambs reported at June census.

BREEDEWES$DEC = Breeding ewes recorded at the December census.

DISSAP = Disapearence from the breeding flock, defined as in text.

SHCULLS = Slaughter of cull ewes and rams.

CULLPER = SHCULLS/DISSAP.

GBTEMP$WINT = Average daily temperature for the months November to March.

TIME$A = Annual time trend.

GBTEMP$FEB = Average daily temperature for February.

LAMBP	=	Lamb returns
CCP	=	Clean cattle price index.
SCOTTEMP$FEB	=	Scottish temperature in February.
LAMBSLGHT1	=	Number of lambs slaughtered in the first half of the calendar year.
LAMBSLGHT2	=	Number of lambs slaughtered in the second half of the calendar year.
EWTEMP$MAY	=	Average daily temperature in England and Wales, for May.
GBTEMP$YR	=	Average GB temperature in the year.
EWTEMP$FEB	=	Average daily temperature in England and Wales, for February.
LAMBPROD	=	Production of lambs and mutton.
MKTLMP	=	Market lamb price.
RPI	=	Retail price index.
MKTCCP	=	Market clean cattle price index.
PIGP	=	Clean pig price index.
LAMBIMP	=	Imports of lamb.
LAMBVP	=	Lamb variable premium payments.
EWEP	=	Ewe price index.
DUMDEC	=	Seasonal dummy, =1 in second period, 0 in first.

Chapter 6

THE PIG SECTOR

(M.P.Burton)

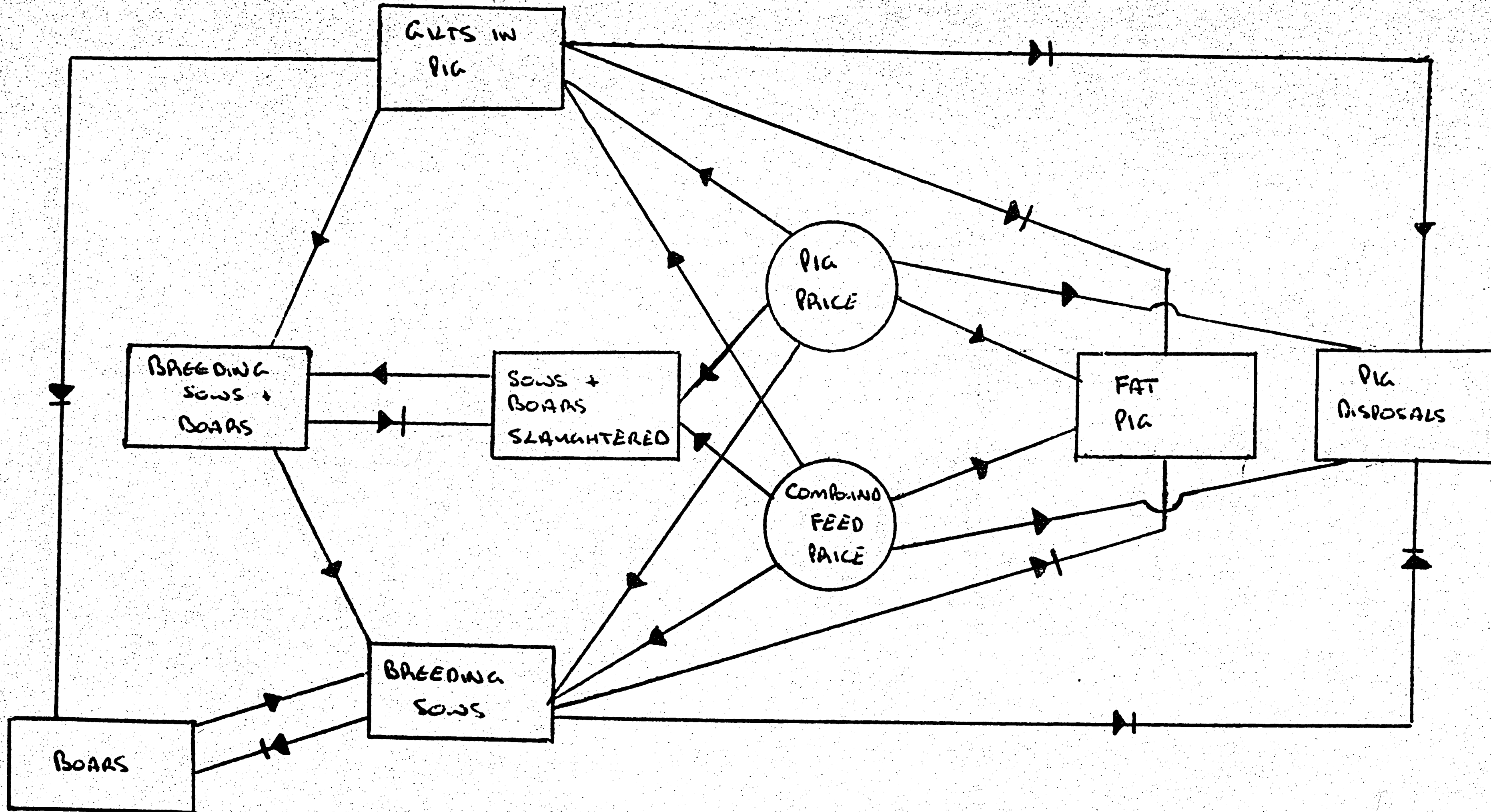
Introduction

There is an established body of literature concerned with modelling the pig sector (i.e. Colman and Young (1979) , Ness and Colman (1976) and Savin (1978)). The current model follows Savins' structure, by determining the breeding herd size through inflow and outflow equations. The major difference from the previous work is that the current model is estimated using semi-annual data, over the period 1969.2 to 1983.2. There is some simultaneity between the slaughtering of pigs and the determination of the pig price, as can be seen from the flow diagram in figure 1, and for these equations a Two Stage Least Squares (TSLS) approach has been used. The following section gives a brief overview of the structure of each equation, with the detailed results being presented in Appendix 6.1.

The Breeding Herd Equation

The pivotal element of the model is the breeding herd identity. It has been necessary to estimate this as a stochastic equation as we do not have a good measure of the inflow into the herd, with the best measure being the gilts in pig at the beginning of the period. Because of the short gestation period this variable does not fully capture all of the inflow, and therefore the gilts in pig at the end of the period is also included. This variable is a proxy, as it cannot directly effect the size of the breeding herd, but it will give an indication of the numbers entering the herd in the last 2 months of the period. There are also some problems with the measurement of the Gilts variable, as it appears to have altered significantly when an additional question was included in the census (see Savin p.), placing doubt on its accuracy. Because of these difficulties it was not felt wise to constrain any coefficients, and, as can be seen, the intercept is significantly

FIG. 6.1



N.B. CIRCLED VARIABLES ARE EXOGENOUS

different from zero, and both the coefficient on the lagged dependent and on the outflow variable are significantly different from unity.

Cull Equation

The outflow from the herd is modelled as a cull ratio, with the denominator being the number of sows, gilts and boars in the breeding herd at the beginning of the period. The explanatory variable is the ratio of the pig price to the compound feed price for pigs, in a quadratic form. A dummy variable GILTDUM is included to allow for the change in the number of gilts in pig that are recorded, as mentioned above.

Gilts in Pig Equation

The number of gilts in pig is again a function of the deflated pig price, with the expected result of a higher price leading to more gilts in pig. The fast response to prices is typical of the pig sector, and the combined value of the coefficients on the lagged dependent variables is only 0.32, implying a fast adjustment. The dummy variable is again introduced.

Pig Disposals Equation

The modelling of pig disposals (recorded slaughterings plus exports from Output and Utilization, split equally between the two halves of the year) can be approached in two ways. The first is to drive it off the number of fat pigs at the beginning of the period, the second is to drive it off the breeding herd at the beginning of the period. Because of the short gestation period, the fast finishing of pigs and the use of a semi-annual periodicity, neither are completely satisfactory in capturing the full potential of pigs for slaughtering. As a result of some experimentation, the breeding herd specification was found to perform best. Thus, the equation is mainly technical, with the implied litter size in the recent years of around 11 piglets. The pig prices seem to affect the timing of slaughtering, with a compensatory effect in the next period.

Fat Pig Equation

With the pig disposals being driven directly by the breeding herd, the number of fat pigs plays a minor role in the model. In fact it is only used in the definition of the pig livestock units which is used to determine the demand for compound feed fed to pigs. It is again driven by the breeding herd size, with some price effects.

Boars Equation

The remaining element is the number of boars. As this is a fairly minor element a simple specification is used, relating the number of boars to the number of sows and gilts. This ratio responds to changes in the breeding herd via a partial adjustment process. Over the period there is evidence of a slight increase in the ratio.

Output Value

The value of pig meat is generated by converting the pig and sow price indices into nominal terms by comparison with prices reported by the MLC for the first period of 1980. These are then multiplied by the numbers of pigs slaughtered in each catagory, and then the values for each half of the year are aggregated together. An adjustment factor is needed to bring the accounting system into line, to allow for the value of offal etc, and the results from the normalised equation are shown in Table 6.1.

Table 6.1

Results from the Normalised Pig Value Equation

	Actual	Simulated	% Error
1978	689.3	680.2	-1.3
1979	744.1	738.6	-0.7
1980	789.7	789.7	0.0
1981	861.6	854.9	-0.8
1982	925.4	919.2	-0.7
1983	916.7	920.1	0.4

Model Simulation

The model has been Simulated over the period 1969.2 to 1983.2, holding all prices exogenous. The U(2) statistics from this simulation are reported in Table 6.2. These are all quite acceptable and, as reference to Figures 6.2 and 6.3 show, the traditional pig cycle has been reproduced within the dynamic simulation.

Table 6.2

Pig Sector Simulation Results

	U(2)
GILTSINPIG	0.5636
S$BSLGHT	0.5782
BREEDSOW	0.6557
FATPIG	0.7140
BOARS	0.8015
PIGDISP	0.8849

The prices that are exogenous to this system have been modelled, and are described in another chapter (9). Because of the specification of the prices, there is a substantial degree of interlinkage between the milk, beef, poultry and pig sectors. Therefore, even if prices are endogenous, a simulation of the pig model in isolation would exclude some of the major feedbacks between sectors, and hence some major influences of the sector on its own prices.

Fig 6.2 BREEDING SOWS

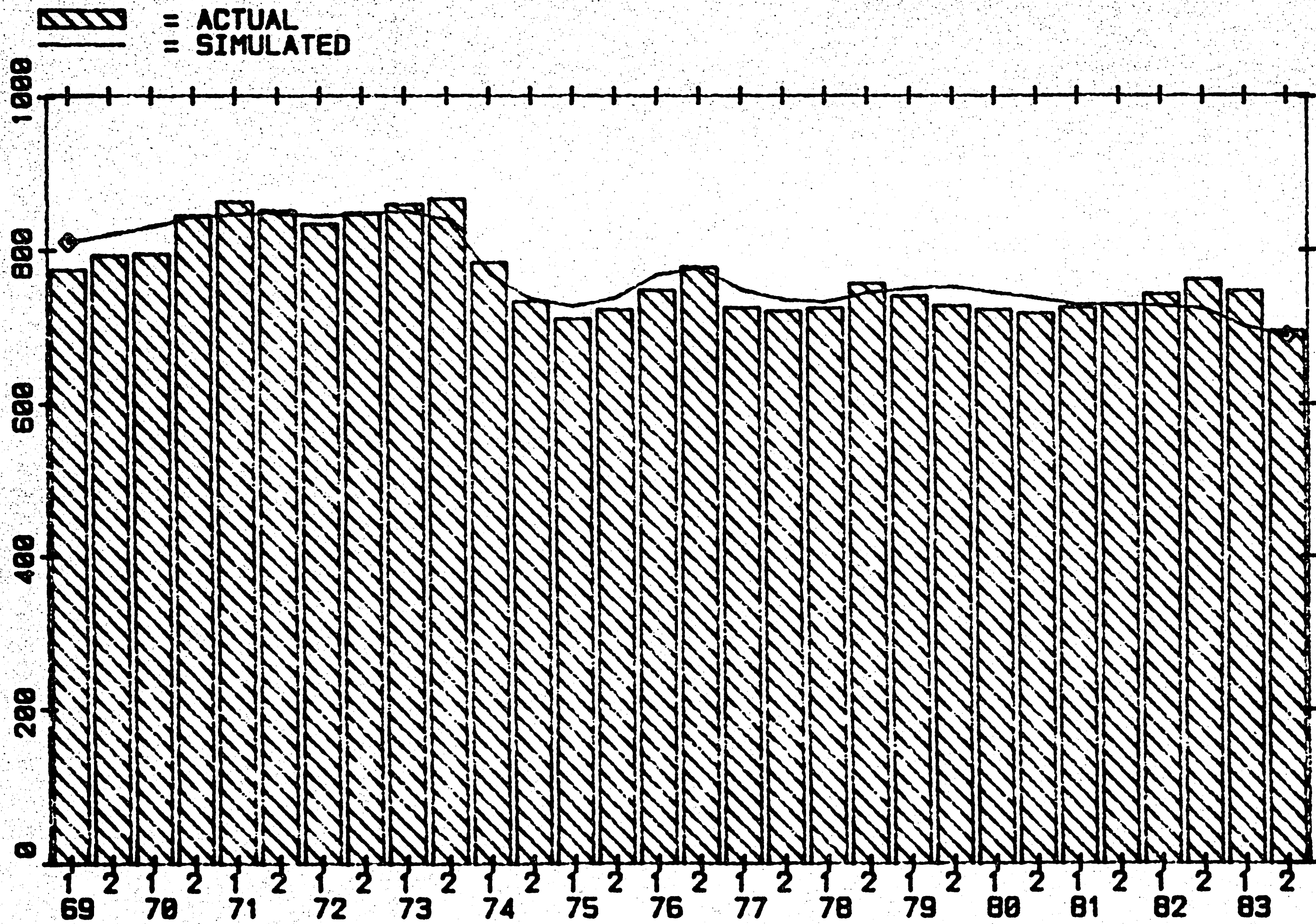
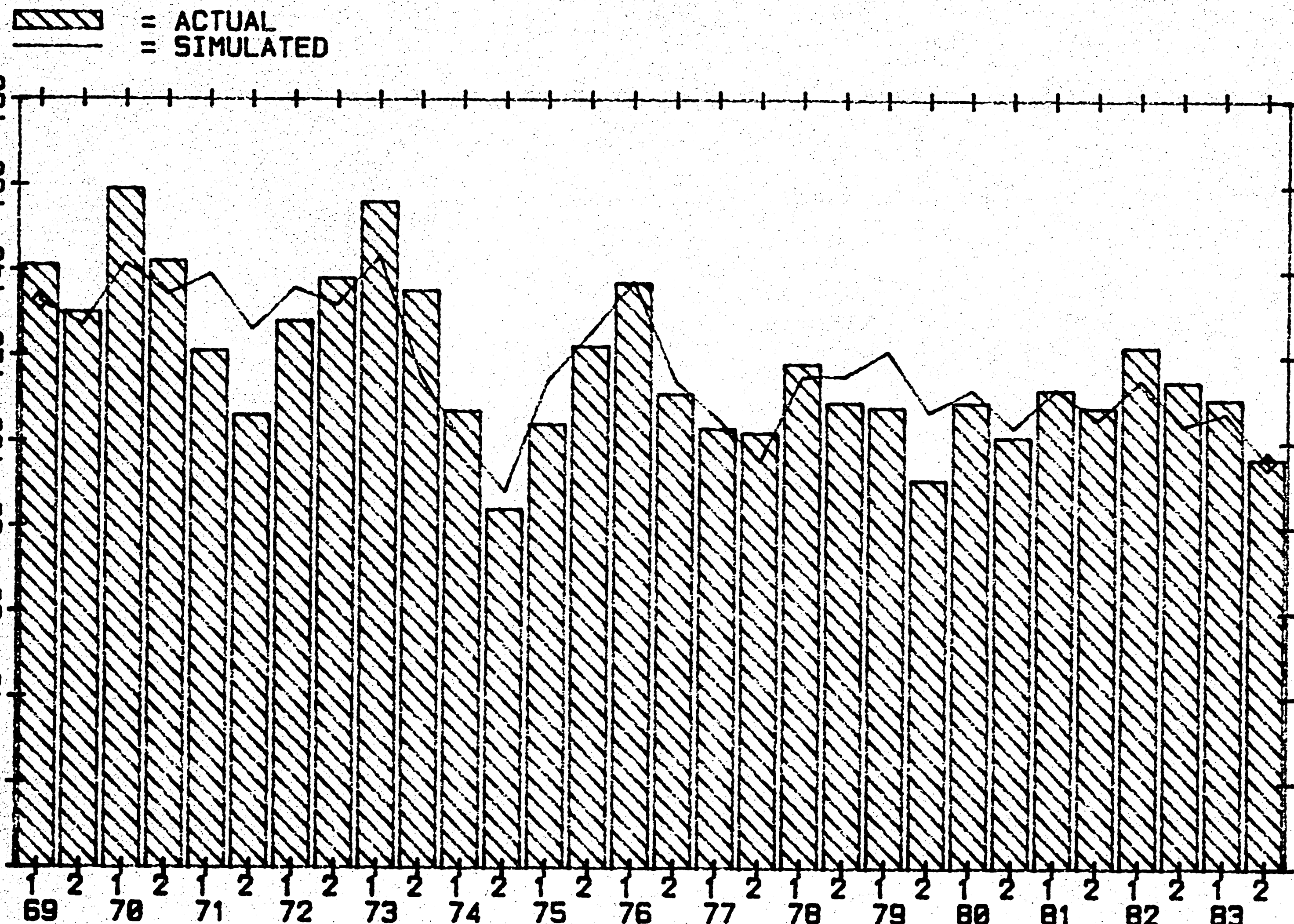


Fig 6.3 GILTS IN PIG



Appendix 6.1

N.B. In order to simplify the presentation of the results the time subscript has been suppressed and an alternative method of denoting lagged variables used. Thus a variable with a time subscript of t-3 is denoted by .3 etc. At times, TSLS has been used to overcome the simultaneity in the system. Where a variable has been replaced by an instrument for the purposes of estimation, the variable is marked with an asterix. Variable definitions are given at the end of the Appendix.

BREEDING HERD EQUATION

```
BREEDSOW + BOARS =  148   +  0.7570*(BREEDSOW.1 + BOARS.1)
                   (3.22)    (9.93)

                          -  0.6549*S$BSLGHT$A
                             (4.26)

                          +  0.8935*GILTSINPIG.1
                             (3.86)

                          +  0.5237*GILTSINPIG
                             (2.43)

R BAR SQUARED = 0.925
F TEST        = 87.6(5,24)
D.h           =
D.F.          = 24
D.V. MEAN     = 810.5
```

CULL RATIO EQUATION

```
CULLR$P  =  0.8165  -  1.114*PIGP/COMPP$P  +  0.0114*GILTDUM.1
            (4.87)     (3.51)                 (1.82)

                    +  0.4857*PIGP*PIGP/(COMPP$P*COMPP$P)
                       (3.24)

CULLR$P  =  S$BSLGHT$A/(BREEDSOW.1 + GILTSINPIG.1 + BOARS.1)


R BAR SQUARED = 0.607
F TEST        = 15.39(4,25)
D.W.          = 1.51
D.F.          = 25
D.V. MEAN     = 0.197
```

GILTS IN PIG EQUATION

```
GILTSINPIG = (56.12  -  0.542*GILTSINPIG.2  +  0.8687*GILTSINPIG.1
             (1.71)    (3.51)                   (7.16)

           + 40.34*PIGP/COMPP$P  -  21.66*DUMDEC)*(1-0.0982*GILTDUM)
             (2.24)                 (6.08)            (2.75)
```

```
R BAR SQUARED = 0.996
F TEST        = 1231(6,23)
D.h           =
D.F.          = 23
D.V. MEAN     = 116.6
```

PIG DISPOSALS EQUATION

```
PIGDISP  =  (5.14 + 0.16*TIME$SA)*(BREEDSOW.1 + GILTSINPIG.1)
            (8.48)  (8.40)

         +  1559*PIGP*/COMPP$P  -  2435*PIGP.1/COMPP$P.1
            (4.45)                 (6.06)

         -  43.96*GILTDUM.1
            (3.10)
```

```
R BAR SQUARED = 0.999
F TEST        = 10153(5,24)
D.W.          = 0.969
D.F.          = 24
D.V. MEAN     = 7150
```

FAT PIG EQUATION

```
FATPIG  =  (5.34 + 0.070*TIME$SA)*(BREEDSOW.1 + GILTSINPIG.1 - 30.65*GILTDUM)
           (15.5)  (6.34)                                       (2.78)

        +  911.8*PIGP/COMPP$P
           (6.01)
```

```
R BAR SQUARED = 0.999
F TEST        = 31814(4,25)
D.W.          = 2.02
D.F.          = 25
D.V. MEAN     = 7208
```

BOAR EQUATION

```
BOARRATIO  =  0.0382  +  0.0417*DELBREED.1  -  0.0444*DELBREED.2
              (18.76)    (4.54)                (4.27)

                      +  0.0198*DELBREED.3  +  0.0004*TIME$SA
                         (2.16)                (5.41)
```

BOARRATIO = BOARS/(BREEDSOW.1 + BREEDSOW.2 + GILTSINPIG.2 + GILTSINPIG.2)

```
R BAR SQUARED = 0.666
F TEST        = 15.0(4,24)
D.W.          = 1.46
D.F.          = 24
D.V. MEAN     = 0.049
```

<u>Variable definitions</u>

BREEDSOW	= Sows for Breeding, not including barren sows.
BOARS	= Boars used for breeding
S$BSLGHT$A	= Sows and Boars slaughtered, adjusted for 53 week statistical years
GILTSINPIG	= Gilts in Pig.
PIGP	= Price Index for slaughtered pigs, excluding sow and boars
COMPP$P	= Price Index of Compound Feed for Pigs
DUMDEC	= Seasonal dummy, =1 in second period of year, 0 otherwise.
GILTDUM	= Dummy variable, =1 from 1973.2 to date, 0 otherwise
PIGDISP	= Pigs Slaughtered, plus an estimate of Pigs exported, adjusted for 53 week statistical years
FATPIG	= All other Pigs, i.e those kept for fattening
TIME$SA	= Time Trend
DELBREED	= Annual Percentage Change in the Breeding Herd i.e $\frac{(BREEDSOW + GILTSINPIG - BREEDSOW.2 - GILTSINPIG.2)}{BREEDSOW.2 + GILTSINPIG.2}$

Chapter 7

THE POULTRY SECTORS

(M.P.BURTON)

Introduction

This chapter outlines the model that has been estimated for the poultry sectors, covering both eggs and meat. The models have taken advantage of recently published work on these sectors, by D. Hallam and M. Ness respectivly, and effectively reproduces the structure of those models. Their work used a quarterly periodicity, which is particularly suitable for these sectors because of the short finishing period for fowl, and the possibilities for a fast response in flock size through chick placings. However, the current MAFF model uses a semi-annual period, and in order to make the poultry system compatible with the rest of the model it also has been estimated using semi-annual data. As a result of this, some modifications to the specifications used by Hallam and Ness where necessary. In the following section we will review the specification of the equations, with detailed results given in Appendix 7.1.

THE EGG SUB MODEL

This sub model is relativly small, consisting of some 4 equations. The relationships between the various elements are shown in the flow diagram in Figure 7.1.

Egg Yield Equation

No economic impacts could be identified as affecting the rise in egg yields, so we have used a quadratic time trend, with a seasonal dummy.

Chick Placings Equation

Following Hallam, the number of chicks placed for entry into the laying flock is in part determined by the size of the laying flock at the beginning of the period, as an indication of the need for replacement hens. The price of eggs deflated by the price of compound feed for poultry has the expected positive effect on chick placings, with an impact

Fig 7.1

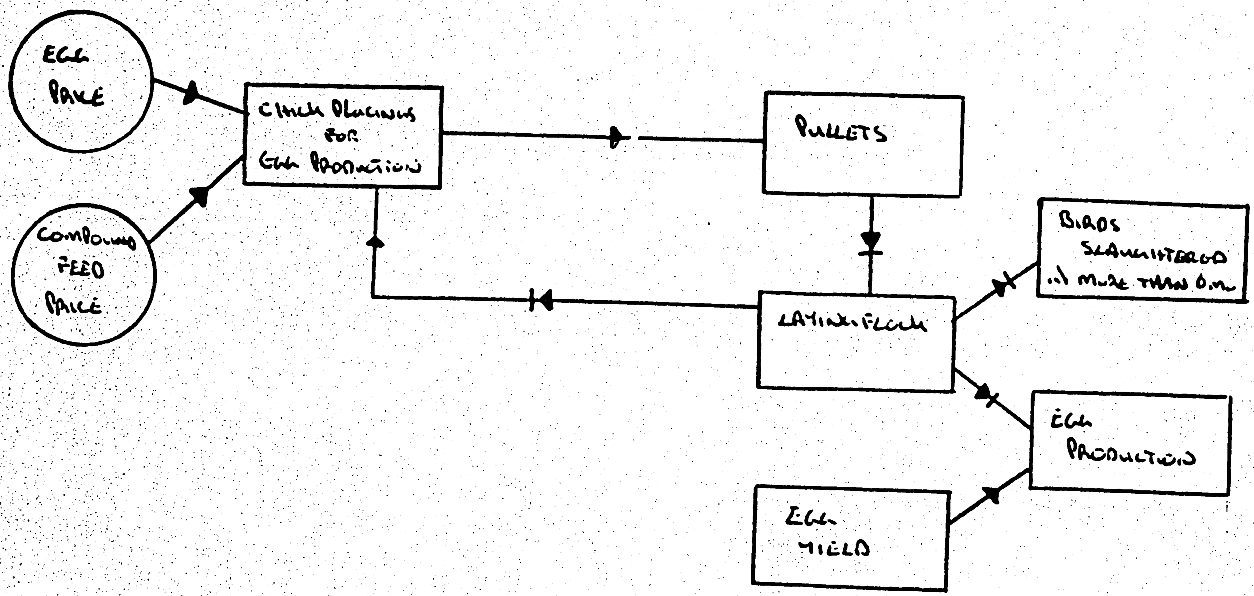
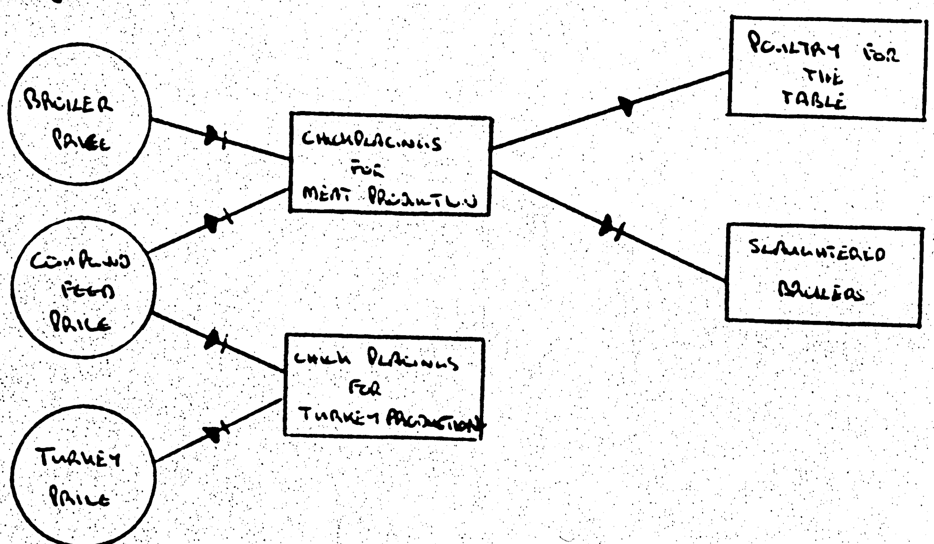


Fig 7.2



N.B. CIRCLED VARIABLES ARE EXOGENOUS

elasticity of 0.55. The long run impact will be larger, as chick placings feed into the laying flock, via the number of pullets.

Pullets Equation

The definition of pullets used in this model differs from that used by Hallam, in that it is the number of pullets not in lay recorded at the census date. Given that the period from placing to point of lay is approximatly 20 weeks, this should be equal to a little less than 80% of the chick placings during the previous six months, with a further adjustment for mortalities. This proportion is allowed to adjust over time, to allow for a decline in the age at which chicks come in to lay. The Durbin Watson indicates problems with serial correlation, but no respecification of the equation could remove this.

Laying Flock Equation

The laying flock is defined as all birds in lay, both for less than 12 months and above. It is a simple equation, using a lagged dependent variable, indicating that some 60% of birds are retained over a six month period, and with the number of pullets (as defined above) lagged six months, representing the inflow into the flock.

Value Equation

The calendar value of egg output is derived by multiplying the output of eggs by the price, and aggregating the two semi-annual values. Output is defined as the egg yield times the average flock size over the period. If the value equation is normalised for the year 1980, there are substantial errors in the following years, as is illustrated by Table 7.1. The cause of this is unclear, and will only be resolved by further investigation into the accounting procedures used by the Ministry.

Table 7.1

Actual and Accounting Values for Egggs

	Actual	Accounting
1978	399.9	397.0
1979	461.8	459.3
1980	488.9	488.9
1981	522.0	503.3
1982	529.0	488.8
1983	496.0	432.4

THE POULTRY MEAT SUB-MODEL

The coverage of the meat sectors has been confined to chickens and turkeys, with a very simple approach being used for the turkeys. The interlinkages between the various equations are represented in Figure 7.2 above.

Meat Chick Placings Equation

The definition of the chick placings is made complicated by the relatively short turn round time for the sector, approximately 11 weeks from placing to slaughter. If the conventional approach of defining the placings over the first six months of the year were used, then those birds would be slaughtered partly in that period, and partly in the following six months. Thus, chick placings are calculated for the six monthly periods April to September, and October to March. These periods are recorded at the point in the middle of this time span. Thus, the chick placings for the period April to September 1984 are recorded as observation 1984.1. By doing this, the slaughterings for the six month period ending December 1984 can be related to the placings recorded at 1984.1. The equation that determines the numbers of Chicks placed takes advantage of data series collected by Ness from NFU data, and which allow a real gross margin figure to be calculated. This is defined as

MSFWD = (WPBC - COST:LB)*LIVEW/(TR*SD*RPI)

where WPBC = Price per Pound live weight

COST:LB = Cost per Pound live weight

LIVEW = Live weight of birds at slaughter

TR = Turn round time in days

SD = Stocking density, birds per square foot

RPI = Retail price index

The quarterly data used by Ness has been converted to semi annual data by simple averaging.

This margin figure, lagged one period, has the expected positive effect on placings, with an elasticity of 0.05. Following Ness, a time trend was needed to explain the strong increase in placings.

Slaughtered Chicken Equation

The dependent variable in this equation is the number of finished broilers. As was outlined above, this can be directly related to the number of meat chicks placed. Given that we have data on mortality and turn-round time it was thought best to incorporate these directly, by adjusting the placings for mortality, and allowing a faster turn round time to reduce the number of chicks placed in the previous period that are slaughtered in the current period. The coefficient on the placings is very close to unity, and there is the expected (small) effect of turn-round time on slaughtering.

Poultry for Table equation

This variable is not needed for generating the value of poultry meat, but the total number of birds in the system will be needed as a demand shifter in the compound feed equation. The numbers of poultry for the table recorded at the census date is a function of the number of chick placings centered on that date, which represents a proxy for the general level of activity in the sector. A time trend was also found necessary to improve the Durbin Watson statistic.

Turkey Chick Placings Equation

The turkey chick placings has been defined in the same manner as for the chickens. The explanatory variables reverts to the conventional product price deflated by compound feed price format, again with a time trend and seasonal dummy.

Slaughtering of Birds aged more than 6 months

This equation is used to capture that element of the slaughterings that are cull birds from the laying flocks (it is assumed that the culls from breeding flocks are negligable). Because this data is reported annually, it has been related to the size of the laying flock at the beginning of the calendar year.

Value Equation

The value of poultry meat is constructed from the two elements, turkeys and chickens. There is no semi- annual data on the slaughtering of turkeys, but it was noted that there was a very close correspondence between the turkey chick placings and the annual slaughterings data, and so the semi annual chick placings was adjusted by a factor of 0.9 and used as proxy for semi annual slaughterings. These were then multiplied by the live weight of the birds, and the price per live pound. In a similar fashion, the summation of broilers and slaughtered birds for a 12 month period had a very close relationship with the total slaughterings, and so an adjustment was included (of approximatly 10%) to bring the series into line. The slaughterings were then multiplied by the live weight and the price per pound live weight to give value. The summation of these two elements then has to be adjusted further, to allow for the value of offal, Ducks, Geese and any other minor adjustments that have been excluded. This was done by zeroing the equation on 1980, and the results from this accounting equation are given in Table 7.2.

Table 7.2

The Accounting Equation for Poultry Value

	Actual	Accounting
1978	443.5	442.8
1979	487.7	494.9
1980	508.4	508.4
1981	515.0	529.1
1982	604.0	612.9
1983	626.0	617.9

Model Simulation

The model has been simulated for the period 1970.2 to 1983.2. The Theil U(2) statistics generated over this period are reported in Table 7.3 below. Most are satisfactory, and as figures 7.3 to 7.6 show, most elements in the evolution of the poultry sectors are captured. The prices that have been held exogenous in this simulation are reported in chapter 9, and mean that the model can be simulated fully, down to the Value of the Outputs. This has not been done because of the strong interlinkages that exist between this sector and the other livestock sectors; and thus, a simulation in isolation will not incorporate all of the feedbacks from the sector on its own prices.

A full simulation of the sector is reported in Chapter 11.

Fig 7.3 TURKEY CHICK PLACINGS

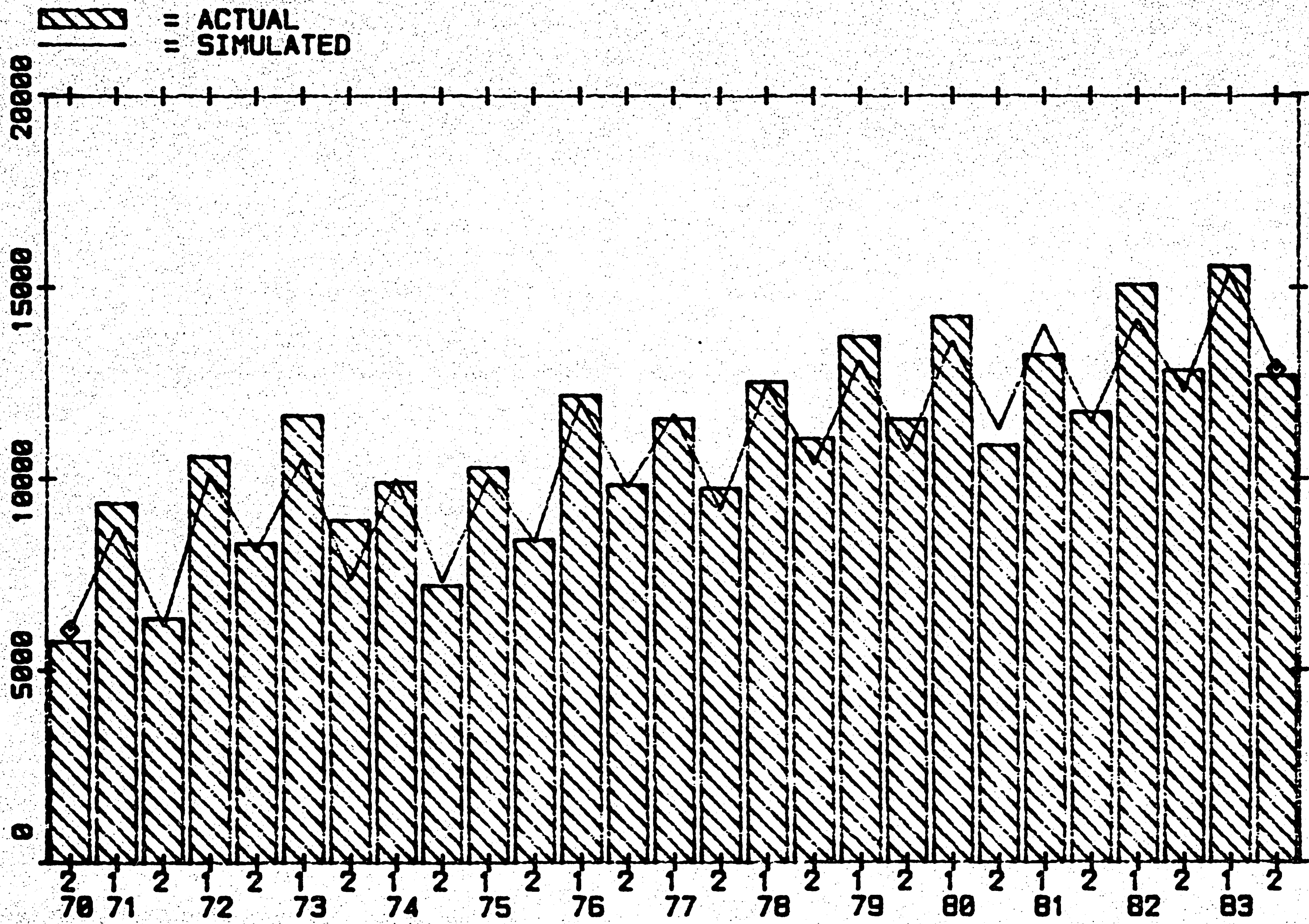


Fig 7.4 EGG CHICK PLACINGS

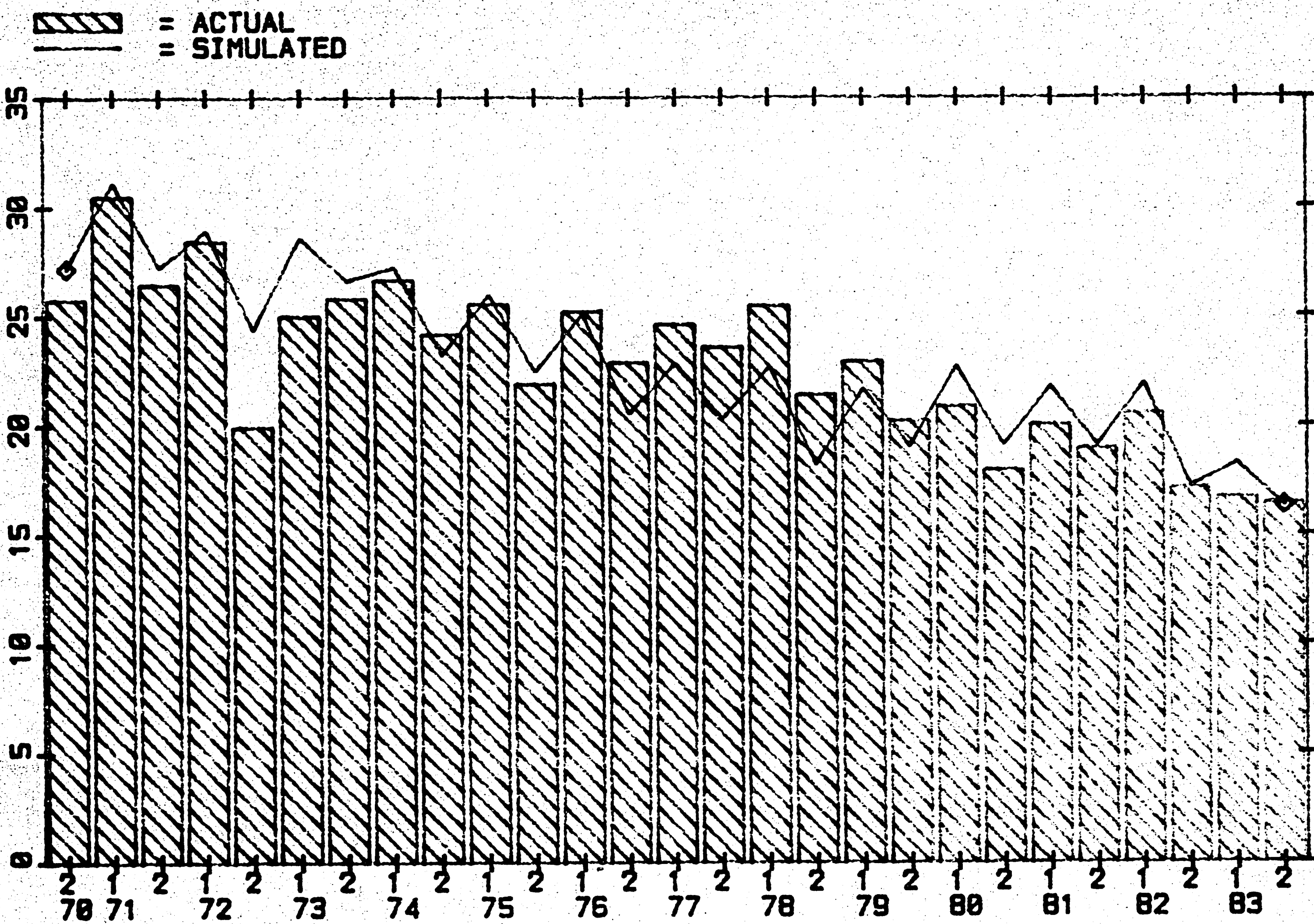


FIG 7.5 MEAT CHICK PLACINGS

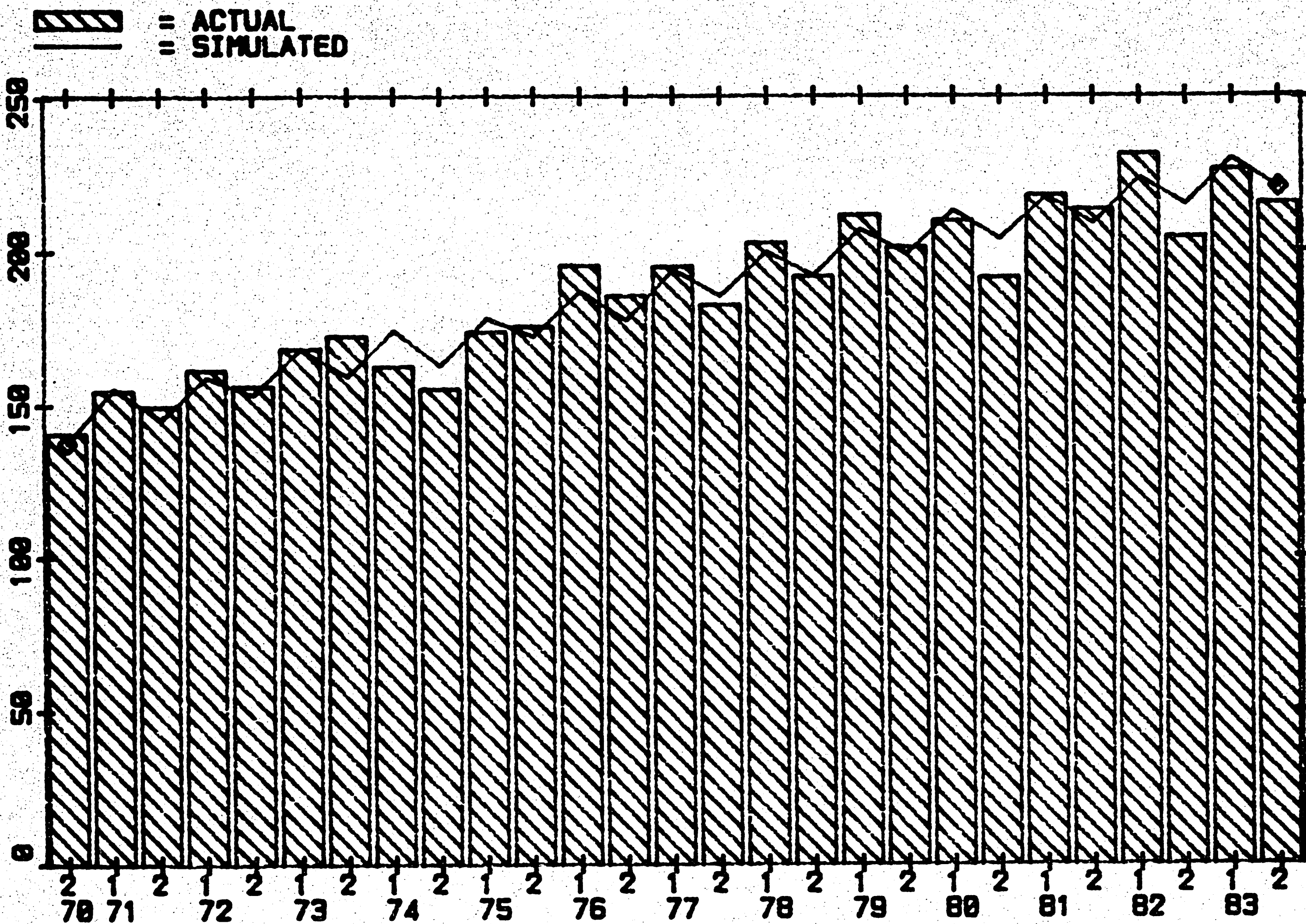
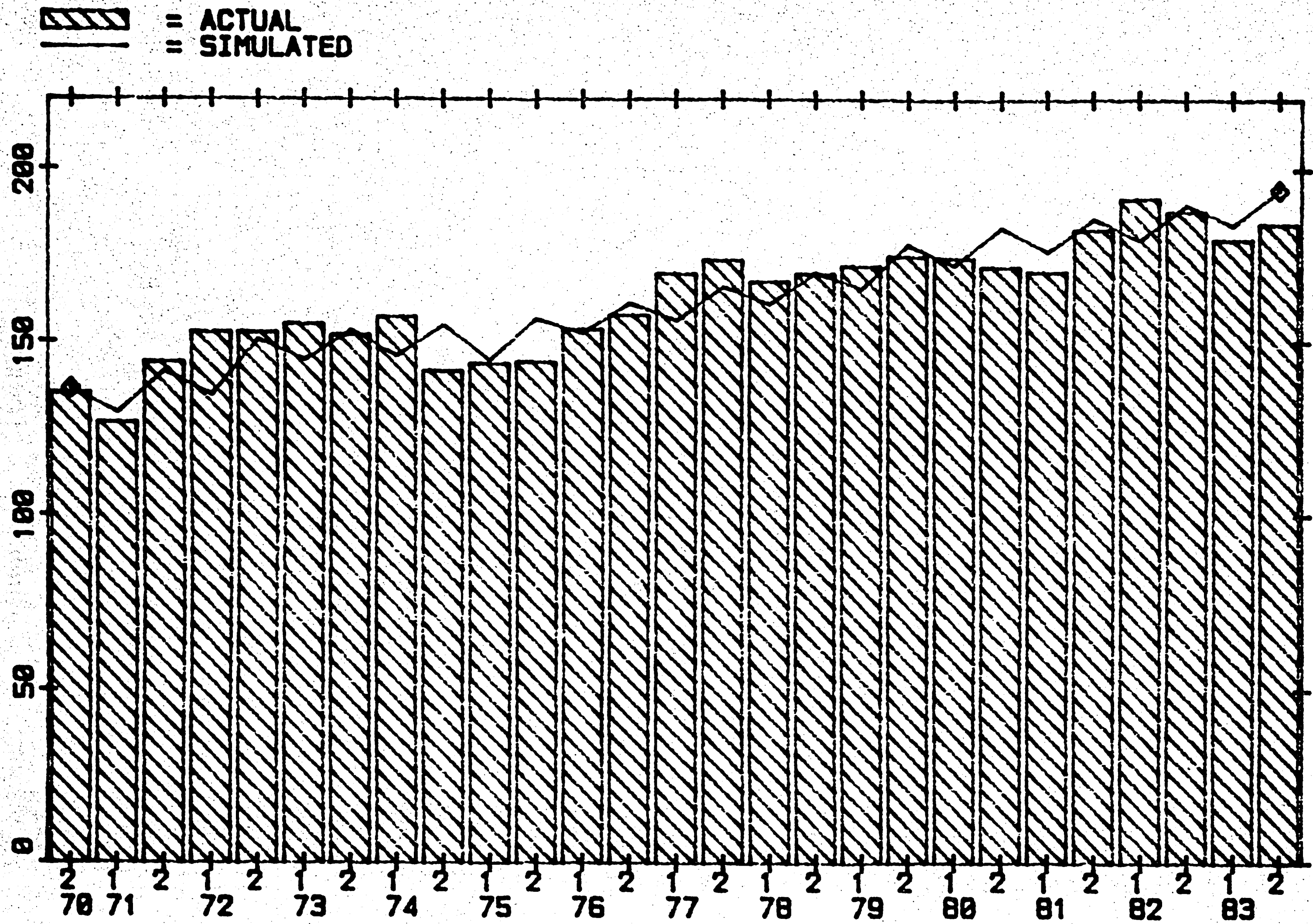


Fig 7.6 No OF FINISHED BROILERS



Appendix 7.1

EGG YIELD EQUATION

```
EGGYIELD =  0.0141   +   5.27E-4*DUMDEC   -  2.81E-4*TIME$SA
            (8.3)        (2.5)               (2.3)

                     -   7.16E-6*TIME$SA*TIME$SA
                         (3.3)
```

R Bar Squared	= 0.872
F TEST (2,28)	= 72
D.W.	= 1.67
d.f.	= 28
D.V. MEAN	= 0.012

CHICK PLACINGS EQUATION

```
CHICKPL$E  =  -11.07  +  (0.409 + 0.0534*DUMDEC)*LAYFLOCK.1
               (2.4)      (3.2)   (3.9)

                      +  7.59*    EGGP
                         (4.6) COMPP$PO
```

R BAR Squared	= 0.835
F Test (3,27)	= 51.8
D.W.	= 1.00
d.f.	= 27
D.V. MEAN	= 23.8

PULLETS EQUATION

```
PULLETS  =  4.74  +  (0.729 - 0.008*TIME$SA)*CHICKPL$E
            (2.8)     (20.2)  (2.7)
```

R BAR Squared	= 0.935
F Test (2,29)	= 222.6
D.W.	= 0.975
d.f.	= 29
D.V. Mean	= 17.26

LAYING FLOCK EQUATION

```
LAYFLOCK  =  8.574  +  0.609*LAYFLOCK.1  +  0.605*PULLETS.1
             (3.2)     (7.2)                (5.4)
```

R BAR Squared	= 0.949
F Test (2,30)	= 296
D.h	= -0.925
d.f.	= 30
D.V. Mean	= 48.9

MEAT CHICK PLACINGS EQUATION

```
CHICKPL$M  =   6.637  +  1057*MSFWD.1  +  6.44*TIME$SA  -  11.56*DUMDEC
               (18.3)    (2.51)           (27.5)            (5.3)
```

R BAR Squared = 0.967
F Test (3,30) = 325
D.W. = 1.74
d.f. = 30
D.V. Mean = 171

FINISHED BROILERS EQUATION

```
QTBC  =  36.9  +  (1.0022  -  0.004*TR)*(1-MORT)*CHICKPL$M.1
         (5.8)    (6.6)       (1.8)
```

R BAR Squared = 0.935
F Test (2,32) = 246
D.W. = 2.06
d.f. = 32
D.V. Mean = 152

POULTRY FOR THE TABLE EQUATION

```
POULT$TAB  =  21.0  -  1.96*TIME$SA  +  0.457*CHICKPL$M.1
             (0.09)    (4.2)            (6.9)
```

R BAR Squared = 0.818
F Test (2,32) = 78
D.W. = 1.44
d.f. = 32
D.V. Mean = 49.6

TURKEY CHICK PLACINGS EQUATION

```
CHICKPL$T  =  -9.45  +  8.82*WPTY.1/COMPP$PO.1  +  0.608*TIME$SA
              (1.9)     (4.6)                      (16.8)

                     -  2.47*DUMDEC
                        (11.5)
```

R Bar Squared = 0.954
F Test (3,22) = 174
D.W. = 1.51
d.f. = 22
D.V. Mean = 10.87

SLAUGHTERINGS OF BIRDS AGED MORE THAN SIX MONTHS

N.B. THIS EQUATION USES ANNUAL DATA

```
SLGHT>6  =  16.7  +  0.492*LAYFLOCK.1
            (1.5)    (2.1)
```

R BAR Squared = 0.26
F Test (1,9) = 4.6
D.W. = 1.99
d.f. = 9
D.V. Mean = 40.4

Variable Definitions

EGGYIELD	=	Yield of Eggs per Bird in the Laying Flock
TIME$SA	=	Time Trend
CHICKPL$E	=	Chick Placings for entry into the Laying Flock
LAYFLOCK	=	Birds in the Laying Flock, all ages
EGGP	=	Price Index for Eggs
COMPP$PO	=	Price Index of Compound Feed for Poultry
PULLETS	=	Birds not yet at Point of Lay
CHICKPL$M	=	Chick Placings for Meat Production
MSFWD	=	Deflated Margin for Broiler Production
DUMDEC	=	Seasonal Dummy = 1 in second period 0 in first
QTBC	=	Slaughter of Finished Broilers
TR	=	Broiler Turn Round Time
MORT	=	Broiler Mortality Rate
POULT$TAB	=	Numbers of Poultry for the Table
CHICKPL$T	=	Chick Placings for Turkey Production
WPTY	=	Price per pound Live Weight of Turkeys
SLGHT>6	=	Slaughter of Birds Aged 6 months or More

Chapter 8

THE COMPOUND FEED SECTOR

(M.P. BURTON)

Introduction

This Chapter reports on the modelling of the demand for compound feed, which represents some 40% of the total value of inputs in the DNIC calculation. The purchases of compound feed have been related directly to the livestock (or output thereof) which consumes the feed. An initial problem of this approach is that there is no semi-annual data on the purchases of feed. There is, however, monthly data on production of compound feeds, the yearly aggregates of which bear a close and consistent relationship with the annual figures for purchases. A further advantage of using this data is that it is disaggregated into more detail than the published estimates of purchases, a feature which is particularly important for the poultry sector.

In the following section the equations will be briefly described, with more detailed results given in Appendix 8.1.

The Cattle Compound Feed Equation

The dependent variable for this equation is the ratio of the quantity of compound feed purchased to the quantity of milk produced during each six monthly period. This ratio is assumed to vary seasonally, and there are also some weather effects. Thus, a dry summer, represented by a high ratio of summer sun to summer rain, will lead to an increase in the purchases of compound feeds during the second half of the year. The milk yield per cow was also found to have a significant effect. The explanation for this may be two fold. Firstly, as milk yields rise then the efficiency of feed conversion may fall, and so the feed:output ratio rise. Secondly, if there has been an increased reliance on purchased feed as opposed to home grown feed then the ratio will show an increase, a trend that will be captured (spuriously) by the trend in yields. It should be noted that the use of a time trend instead of the milk yield did not give superior results. Also, no price effects were found to be significant.

The Pig Compound Feed Equation.

The use of compound feed for pigs has been related to the average number of pig livestock units over the period. Following Colman et al, sows, boars and gilts are given equal weight, with the fat pigs carrying a weight of 0.2. The (quadratic) lagged pig price has the expected effect of increasing demand as the price of the product rises relative to that of feed.

The Compound Feed for Poultry Equation : Eggs

The demand for compound feed for eggs is driven partly by the production of eggs, which has the expected positive effect, but also by the current price of eggs deflated by the price of feed, and the deflated price lagged two periods. For both prices, higher egg prices induce a greater demand for feed, presumably as it becomes profitable to feed more.

The Compound Feed for Poultry Equation : Broilers

The demand for broiler feed during a six month period is related to the number of chick placings centred on the beginning of the period. The numbers of birds are adjusted for the live weight of the birds at slaughter to allow for the extra feed needed to raise the birds to higher weights. The expected positive response to higher product prices relative to feed prices is present, although this seems to follow some adaptive path.

The Compound Feed for Poultry Equation : Turkeys.

Compounds fed to turkeys is largely a function of the number of chicks placed, but there is also a price effect. The relevent price was the turkey price deflated by the feed price, lagged two periods. As the production of turkeys is seasonal, it is to be expected that farmers would base their judgements upon the prices they recieved in the same half of the previous year.

The Compound Feed for Poultry Equation : Others.

The data used records a further category of compound feed, which is the balancers and other feeds. This is a minor element, but it has been modelled separately. It was found to be a positive function of the sum of the other feeds, with a seasonal effect, and a declining trend over time. It was also found to be negatively related to the lagged, deflated egg price. The reason for the latter is unclear, but the variable has been left in the equation.

Value Equations

Because the DNIC records the values of the individual compound feeds, it has been possible to generate values within the model at the same level. Thus, the procedure adopted was to derive an index of value by multiplying the quantity by the price index, and aggregating over the two periods of the year to give an annual figure. This is then zeroed with reference to 1980, and the results from these accounting equations are given in Table 8.1. An additional equation has been estimated for the value of calf feed, which is related directly to the value of cattle feed.

So far, we have been dealing with compound feeds only, but the value of feeding stuffs given in the DNIC includes elements such as straights, non-concentrates and other costs. Comparison of the sum of the values of the compound Feeds relative to the total value of all feedingstuffs shows that there is a fairly constant difference, and so the two were regressed to generate a total value equation which is driven by the compound feed equations. This equation is reported in the Appendix. The results for the accounting equation for all feeding stuffs is given in the final column of Table 8.1.

Table 8.1

Results from the Value Accounting Equations

	Poultry		Cattle		Pigs		All Feeding Stuffs	
	Act.	Acc.	Act.	Acc.	Act.	Acc.	Act.	Acc.
1978	455.9	457.6	484.8	487.7	284.6	277.1	1774.3	1804.8
1979	509.0	513.7	599.9	608.3	324.3	324.9	2089.2	2103.8
1980	538.1	538.1	611.5	611.5	332.8	332.8	2187.5	2173.5
1981	589.1	584.1	641.1	647.8	349.0	352.2	2282.3	2312.1
1982	648.8	648.3	742.1	751.0	387.7	391.2	2611.6	2601.3
1983	696.2	688.3	855.3	889.2	438.1	421.3	2860.5	2900.4

Simulation of the Compound Equations

The compound feed equations have been simulated over the period 1971.1 to 1983.2 and the Theil U(2) statistics are given in Table 8.2. These are largely satisfactory, an observation which is supported by Figures 8.1 to 8.4, which reproduce the simulation results. The exception is the compound feed for broilers, which has a U(2) statistic of slightly more than unity. Figure 8.1 reveals that the absolute size of the errors is not excessive, but that there appears to be some serial correlation in the simulation error, especially in the period 1976 to 1981.

Table 8.2

Theils U(2) statistics for Compounds

Turkeys	0.247
Broilers	1.044
Layers	0.696
Cattle	0.529
Pigs	0.501

Fig 8.1 BROILER COMPOUNDS

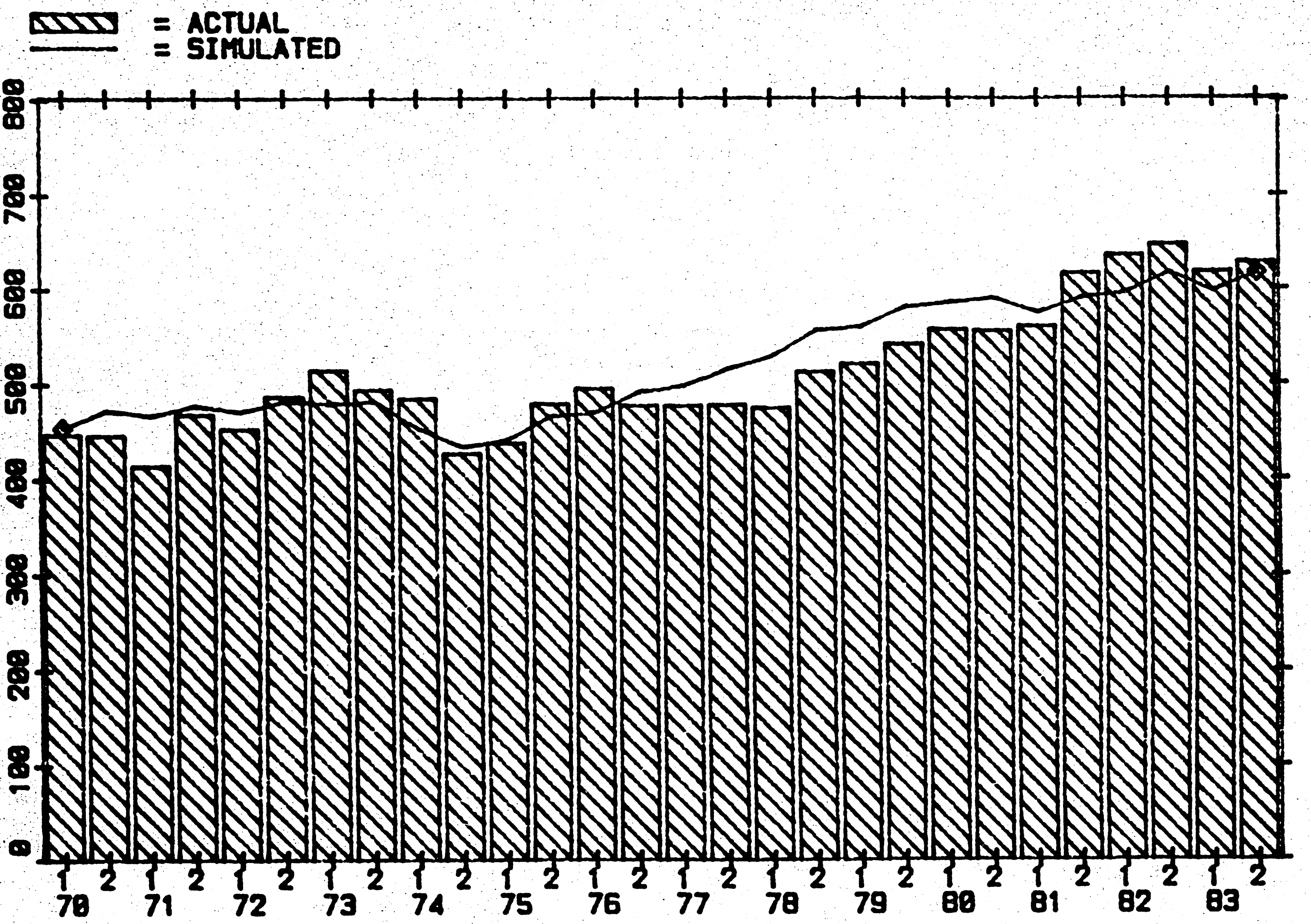


Fig 8.2 LAYERS COMPOUNDS

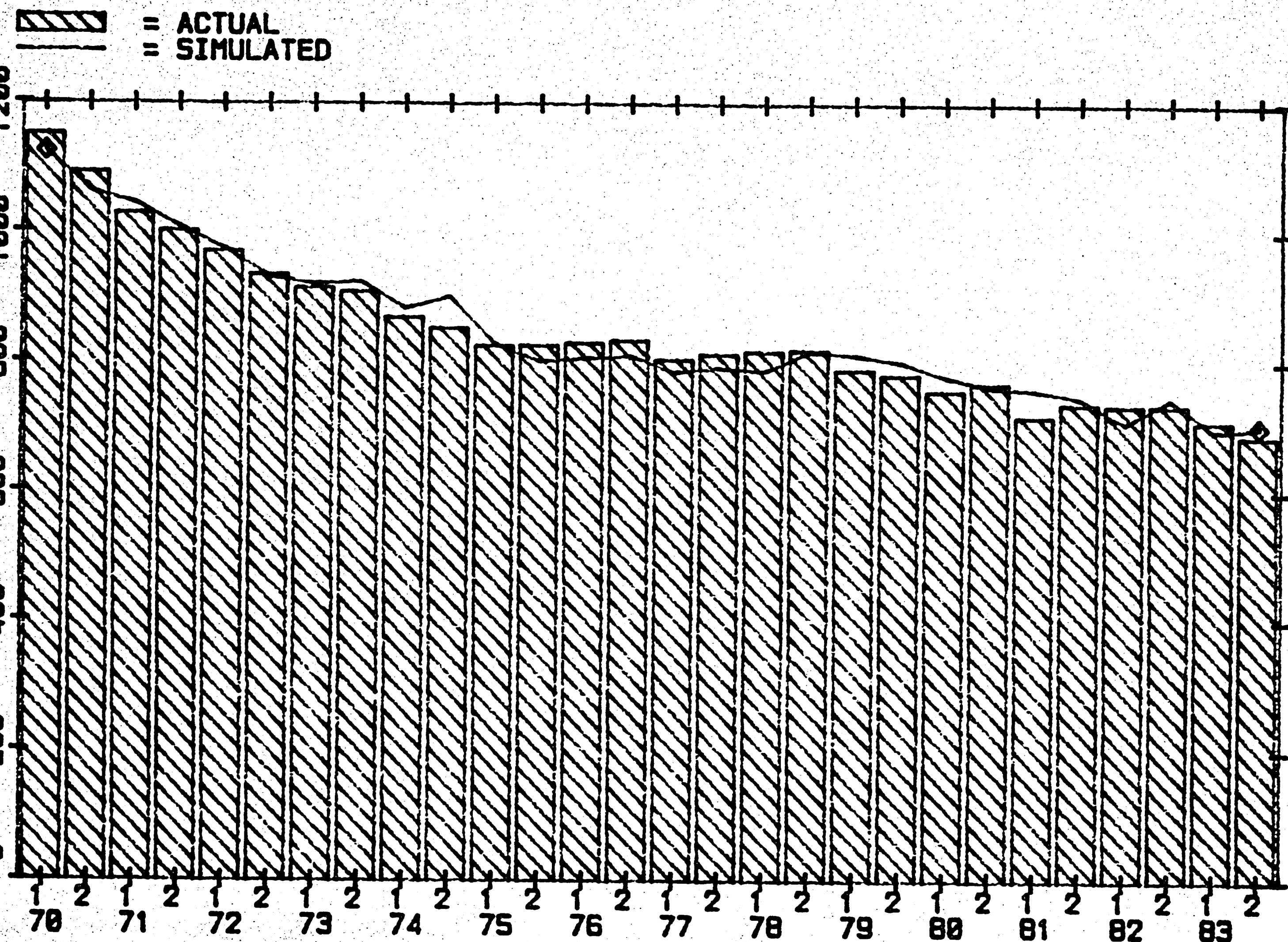


Fig 8.3 CATTLE COMPOUND FEEDS

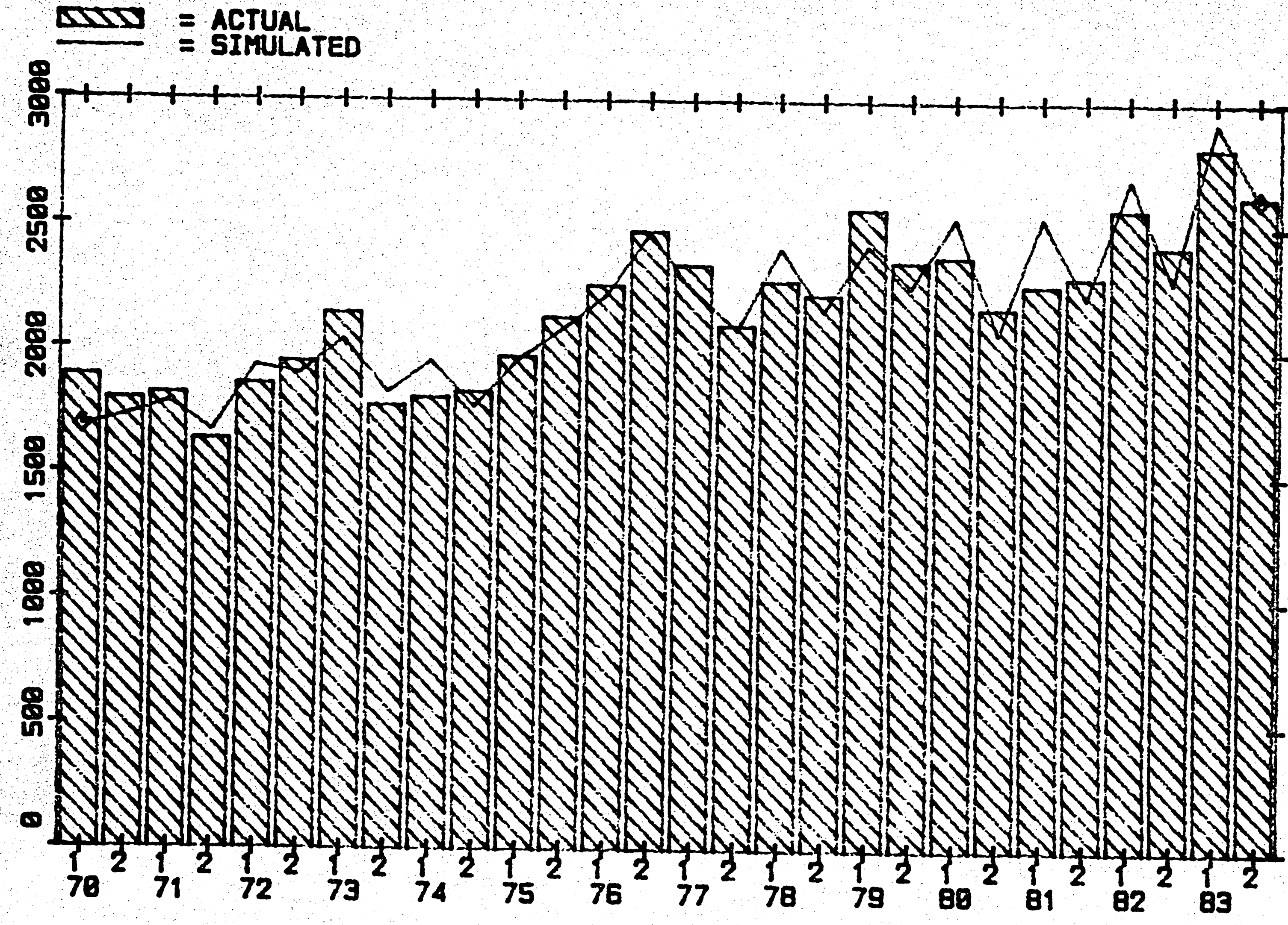
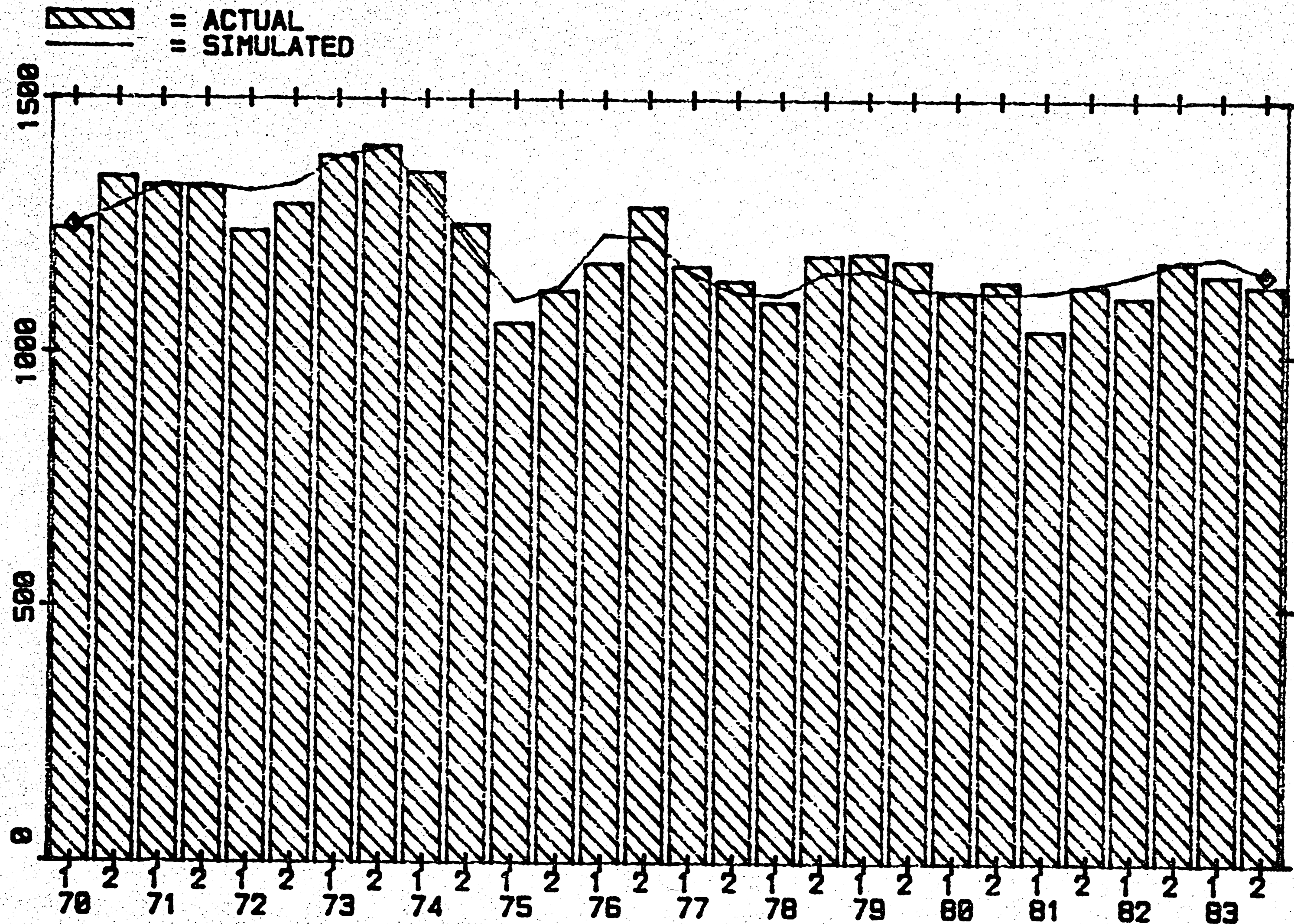


Fig 8.4 PIG COMPOUND FEED



Appendix 8.1

CATTLE COMPOUND FEED EQUATION

$$\frac{COMPFEED\$C}{MILKOUTPUT} = \underset{(9.2)}{0.1668} - \underset{(3.3)}{0.0251}*DUMDEC + \underset{(6.8)}{0.0000594}*MILKYIELD + \underset{(7.5)}{0.426}*DUMDEC*(SUN{:}RAIN\$JJA)$$

R Bar Squared = 0.708
F Test (3,43) = 38
D.W. = 2.25
d.f. = 43
D.V. mean = 0.292

PIG COMPOUND FEED EQUATION

$$COMPFEED\$P = \underset{(1.0)}{485} + \underset{(10.7)}{0.626}*(PIGLSU + PIGLSU.1)/2 - \underset{(1.7)}{1581}*\frac{PIGP.1}{COMPP\$P.1} + \underset{(1.8)}{807}*\frac{PIGP.1*PIGP.1}{COMPP\$P.1*COMPP\$P.1}$$

R BAR Squared = 0.833
F Test (3,25) = 47
D.W. = 1.85
d.f. = 25
D.V. Mean = 1210

COMPOUND FEED FOR LAYERS EQUATION

$$COMP\$EGG = \underset{(1.8)}{219} + \underset{(7.3)}{1.45}*EGGPROD - \underset{(3.6)}{409}*\frac{EGGP}{COMPP\$PO} - \underset{(1.2)}{142}*\frac{EGGP.2}{COMPP\$PO.2} + \underset{(4.5)}{161}*\frac{EGGP*EGGP}{COMPP\$PO*COMPP\$PO} + \underset{(2.2)}{79.5}*\frac{EGGP.2*EGGP.2}{COMPP\$PO.2*COMPP\$PO.2}$$

R BAR Squared = 0.965
F Test (5,22) = 170
D.W. = 1.41
d.f. = 26
D.V. Mean = 829

COMPOUND FEED FOR BROILERS

$$COMP\$BROIL = \underset{(1.5)}{-154} + \underset{(5.6)}{0.725}*COMP\$BROIL.1 + \underset{(3.5)}{0.194}*CHICKPL\$M.1*LIVEW + \underset{(2.2)}{363}*WPBC/COMPP\$PO$$

R BAR Squared = 0.886
F Test (3,25) = 74
D.h = 0.761
d.f. = 25
D.V. Mean = 510

COMPOUND FEED FOR TURKEYS

$$COMP\$TURK = \underset{(2.7)}{-95} + \underset{(10.9)}{0.0155} * CHICKPL\$T.1 + \underset{(3.9)}{204} * WPTY.2/COMPP\$PO.2$$

R BAR Squared = 0.826
F TESt (2,23) = 60
D.W. = 1.80
d.f. = 23
D.V. Mean = 182

COMPOUND FEED FOR POULTRY: OTHERS

$$COMP\$PO\$OTH = \underset{(3.9)}{135} - \underset{(1.8)}{4.77} * DUMDEC - \underset{(9.2)}{5.69} * TIME\$SA$$

$$- \underset{(9.2)}{28.1} * \frac{EGGP.1}{COMPP\$PO.1} + \underset{(4.2)}{0.0763} * (COMP\$TURK + COMP\$EGG + COMP\$BROIL)$$

R BAR Squared = 0.922
F Test (4,26) = 90
D.W. = 0.896
d.f. = 26
D.V. Mean = 48

CALF FEED VALUE EQUATION

$$CALFFEEDVAL = \underset{(0.09)}{0.0619} + \underset{(73.3)}{0.1157} * CATFEEDV$$

R BAR Squared = 0.997
F Test (1,17) = 5372
D.W. = 1.56
d.f. = 17
D.V. Mean = 33

TOTAL FEED VALUE EQUATION

$$FEEDVAL = \underset{(2.7)}{63.3} * DUMDEC$$

$$+ \underset{(87.7)}{1.36} * (CATFEEDVAL+CALFFEEDVAL+PIGFEEDVAL+POULTFEEDVAL)$$

R BAR Squared = 0.9997
F Test (2,16) = 28158
D.W. = 1.70
d.f. = 16
D.V. Mean = 1028

Chapter 9

THE PRICE SYSTEM

Covering the Livestock Complex

(M.P.BURTON & D.R.COLMAN)

Introduction

This paper outlines the price equations that have been estimated for the beef, milk, pig and poultry sectors. It covers both the product prices and the input prices for these sectors, but extends beyond the boundaries of these sectors to include the prices of wheat and barley which are the main determinants of the compound feed prices. It does not include all price equations within the model, for example the horticulture and sugar beet prices are reported in the papers covering those sectors (Chapters 3 and 2 respectively). The reason that this has not been done for the prices reported in this Chapter is that there is a strong degree of inter-dependence between the sectors, which makes it convenient to report them as a group.

Fig. 9.1 below contains a flow diagram that shows the major relationships between the various components. The physical stocks and flows are not fully reported: these are shown in their respective Chapters. The major interlinkages occur between the cattle and pig prices, where a degree of simultaneity occurs. When there is institutional price support for a product, then this is used as the major determinant of the price. Otherwise, the supply of the product is the usually the main element. All prices have been estimated using semi annual data, usually for the period 1973 to 1983, although there are some exceptions to this.

In the following section the structure of each equation is described, with the detailed results given in Appendix 9.1.

Cereals and Compound Feeds

Wheat Price Equation

The main elements determining the wheat price are the policy prices, i.e. the Intervention and Effective Threshold prices. Following Colman (1985) it was thought that the influence of each would vary depending on the half of the harvest year. Thus in the first half, when stocks are high, the Intervention price is more likely to be supporting the price, whereas in the second half the Threshold price will have more effect. In order to accommodate this a composite variable was constructed which was equal to the Intervention price in the first period of the harvest year (second period of the calender year) and equal to a weighted average of the two policy prices in the second period. At first the weight used was the size of on farm stocks as a proportion of harvested output, so that as the size of the stocks increased greater weight was given to the intervention price. However, the proportion of the output harvested that is still on farm at December stays fairly constant, at around 50%, and so fixed weights were also tried, giving a 50-50 weight to each policy price in the second period. This gave almost equivalent results, and as it is simpler to incorporate in the model, this structure was used.

The dependent variable used is the wheat price index, deflated by the composite policy price. The undeflated price, with the (undeflated) policy price on the right hand side, was also tried, but the current specification gave a slight improvement in terms of the Durbin-Watson statistic. The explanatory prices used are the Import price of wheat, deflated by the Threshold price. This has the expected positive impact, as does the number of birds recorded for the table at the beginning of the period, which is used as a demand shifter. The production of wheat also has the expected negative effect on price, although the significance is not large. One would expect production to have some effect, as the support offered by the policy is not perfect, and output will also in part determine the position of the price within the bounds of the policy prices.

Barley Price Equation

The barley price follows the same format as the wheat price, with the dependent variable being the price index deflated by the composite policy price for barley. The explanatory variables are the (policy) deflated wheat price, and the production of barley.

Compound Feed Price : Poultry

The compound feed prices have each been related to the price of the cereal which is the major component in it. Thus, the poultry compound feed price index is deflated by the wheat price. This ratio is remarkabley constant, and hence the low R Bar Squared does not cause too much alarm. A point that was noted however, was that there appears to be some assymetry in the response of the compound price to changes in the wheat price. Thus, when the wheat price rises, the compound price follows, but when the wheat price falls, the compound price does not fall immediately. In an attempt to capture this, a fairly complex dummy variable was constructed. Firstly, a variable called WHEATRAT was calculated, defined as

$$1 - \frac{WHEATP}{WHEATP.1}$$

Next, if the value of this variable was negative then the value was constrained to equal zero. The effect of this is that if the nominal price of wheat rises, then the variable is set to zero. However, if the nominal price falls then the variable is equal to the absolute value of the percentage change. Thus the greater the fall in the wheat price, the greater the increase in the ratio of the compound to the wheat price. This is obviously a highly simplified form, as it requires a fall in the nominal price before the effect is triggered. Also, the effect is assumed to last only for the period in that the fall occurs, something justified by the fact that experimentation with lagged values of this variable (implying some adjustment path) did not yield significant results. There may be some scope for a more elaborate investigation using the techniques outlined in Burton (1985).

The numbers of birds recorded as for the table at the begining of the period has also been included as a demand shifter and has the expected positive effect.

Compound Feed Price Equation : Cattle

The compound feed for cattle price index is determined by the barley price, and a dummy variable similar to that used for the poultry compound feed price. Milk output in the previous period is used as a demand shifter, as it should be a better proxy for the potential demand for feed than the size of the dairy herd.

Compound Feed Price Equation : Pigs

This equation is of exactly the same form as that for the cattle feed price, except the number of pig livestock units at the begining of the period is used as the demand effect. All variables are significant and of the expected sign, although the very high level of fit is due partly to the dependent variable being undeflated.

Milk and Clean Cattle Prices

Milk Price Equation

In theory, the price received by farmers for their milk is determined by two prices, the price of liquid milk and the price for manufactured milk. Thus it is possible to derive an average price, consisting of a weighted average of these two prices, where the weights are constructed from the proportion of milk consumed as liquid, and the proportion used for manufacture. The price for manufacture can be said to consist of the average of the intervention prices for butter and skim milk powder, weighted according to the physical composition of the milk. In fact, the price received in each period is not equal to the Average price due to the administrative cost to the MMB, which has to be subtracted, and also because there may be some time needed for the milk price to be adjusted as prices, or quantities sold in each market, adjust. What we have done is to deflate the milk price by the average price, and allow this ratio to adjust to its equilibrium value.

Clean Cattle Price Equation

The use of the variable premium system for beef makes modelling the returns to farmers a little more complicated. The first stage is to model the market price of clean cattle. This is deflated by the retail price index, and is a function of the cattle target price, similarly deflated. It is also a function of the quantity of steers and heifers slaughtered, and the number of pigs slaughtered, both of which depress the price received. This is only the first part of the payment, however. If the price is less than the target price, then a variable premium is paid to bring the total received up to the target price, subject to the limit that the premium cannot exceed a maximum value. This is achieved within the model by defining the variable premium paid as follows,

$$CCPVP = (CATTGP - MKTCCP)*D1 - (CATTGP - MKTCCP - MAXCCPVP)*D2$$

where CATTGP = Clean cattle target price

MKTCCP = Market price achieved for clean cattle

MAXCCPVP = Maximum payable variable premium

D1 = Dummy Variable = 1 if CATTGP-MKTCCP is positive
0 otherwise

D2 = Dummy Variable = 1 if CATTGP-MKTCCP > MAXCCPVP
0 otherwise

It is possible to generate the dummy variables endogenously within the model, so that the value generated for the variable premium is consistent with the value generated for the market price.

Clean Cattle Price Index Equation

The current variable premium system has been in operation since 1975, but it was thought inappropriate to constrain the estimation of the livestock sectors etc. to this short period. Instead, the clean cattle price index (as reported by the Ministry) has been used in these models (see, for example, Chapter 4). It has therefore been necessary to link the clean cattle price index and the price generated by the combination of the market price and the variable premium. This has been done by simply adding the latter two, and regressing the total against the clean cattle price index.

Fat Cow Price Equation

Although not used in the stock equations, the price of cull cows is needed when generating the value of meat produced. The deflated fat cow price is explained by the market price of clean cattle, the slaughterings of cows and bulls, and a time trend.

Clean Pig Price Equation

The determination of the pig price represents the central hub of the price equations, as it is simultaneously determined with pig slaughterings, and thus with the cattle price. In order to overcome these problems Two Stage Least Squares has been used. The pig price (deflated by the RPI) is assumed to adjust to its equalibrium value over time, but the coefficient of 0.38 on the lagged dependent implies a fairly fast adjustment. The numbers of pigs and broilers slaughtered have the expected negative effect on the price, whereas the price of clean cattle has a positive impact on the pig price.

Sow Price Equation

The sow price is not used in the stock equations, but it is needed for generating the value of pig meat. It is a simple partial adjustment equation, with the prices of the clean pigs and cattle as the other exogenous variables. The fit is not high, and there are some movements in the price that seem perverse when compared with the other meat prices, but as it plays a fairly minor role in the model the equation is thought acceptable.

Poultry Equations

Egg Price Equation

The (deflated) price of eggs is assumed to be dependent upon the level of real disposable income, and a strong downward time trend, with some partial adjustment.

Turkey Price Equation

As there are no figures for the slaughterings of turkeys on a semi annual basis, the chick placings prior to the period have been used as a proxy. The deflated price of broilers has the expected positive effect on the price, as they are presumably a strong substitute for turkey. The price also follows an adjustment path to equilibrium, with the combined coefficient on the lagged dependents being 0.26.

Broiler Price Equation

The broiler price is assumed to be determined by the deflated pig price, and the number of broilers that are slaughtered in the period. There is some degree of partial adjustment, but this is fairly fast.

Production Cost per pound of Broilers Equation

Because the broiler model makes use of the NFU costings data, it is possible to use the reported cost per Lb liveweight for broilers in constructing a gross margin for broiler production (see Chapter 7). It is then necessary to model this element. As it was thought that feedingstuffs were the principle element of costs, the price of compound feed is an important element in the equation. However, some other technical variables that are reported in the NFU costings were also found to be significant. Thus, the stocking density and the mortality rate of birds was found to increase the costs, whereas the liveweight that they are reared to is found to decrease the cost per pound.

Appendix 9.1

WHEAT PRICE EQUATION

$$\frac{\text{WHEATP}}{\text{PPW}} = \underset{(0.3)}{0.108} + \underset{(7.7)}{0.437}*\frac{\text{CIFW}}{\text{WETP}} + \underset{(2.4)}{0.0122}*\text{POULT\$TAB} - \underset{(1.5)}{2.01\text{E-}5}*\text{WHEATPROD}$$

R BAR Squared = 0.837
F TEST (3,19) = 38.6
D.W. = 1.42
d.f. = 19
D.V. Mean = 1.088

BARLEY PRICE EQUATION

$$\frac{\text{BARLEYP}}{\text{PPB}} = \underset{(1.5)}{0.289} + \underset{(20.7)}{1.18}*\frac{\text{WHEATP}}{\text{PPW}} - (\underset{(2.0)}{0.0333} - \underset{(1.6)}{0.0042}*\text{DUMDEC})*\text{BARLEYPROD}$$

R BAR Squared = 0.969
F Test (3,19) = 233
D.W. = 1.43
d.f. = 19
D.V.Mean = 1.27

COMPOUND FEED PRICE EQUATION: POULTRY

$$\frac{\text{COMPP\$PO}}{\text{WHEATP}} = \underset{(20.7)}{0.869} + \underset{(4.8)}{0.891}*\text{DUMWP:RAT} + \underset{(2.6)}{0.00223}*\text{POULT\$TAB}$$

R BAR Squared = 0.376
F Test (2,36) = 12.4
D.W. = 2.09
d.f. = 36
D.V.Mean = 0.988

COMPOUND FEED PRICE EQUATION : CATTLE

$$\text{COMPP\$C} = \underset{(4.8)}{-16.4} + \underset{(40.0)}{0.867}*\text{BARLEYP} + \underset{(2.0)}{25.0}*\text{DUMBP:RAT} - \underset{(4.2)}{0.0029}*\text{MILKOUTPUT}$$

R BAR Squared = 0.991
F Test (3,48) = 1946
D.W. = 1.44
d.f. = 48
D.V.Mean = 52.3

COMPOUND FEED PRICE INDEX : PIGS

```
COMPP$P  =  -19.3  +  0.99*BARLEYP  +  38.1*DUMBP:RAT
            (3.3)    (70.7)            (2.8)

                   +  0.0062*PIGLSU.1
                      (2.4)
```

R BAR Squared = 0.99
F Test (3,47) = 1724
D.W. = 1.39
d.f. = 47
D.V.Mean = 54.7

MILK PRICE EQUATION

$$\frac{MILKP}{AVMILKP} = \underset{(5.0)}{0.224} + \underset{(14.9)}{0.726} * \frac{MILKP.1}{AVMILKP.1}$$

R BAR Squared = 0.94
F Test (1,13) = 221
D.W. = 2.1
d.f. = 13
D.V.MEAN = 0.879

CLEAN CATTLE MARKET PRICE EQUATION

$$\frac{MKTCCP}{RPI} = \underset{(3.4)}{0.537} + \underset{(4.1)}{1.15} * \frac{CATTGP}{RPI} - \underset{(5.8)}{0.000204} * SHSLGHT\$A + \underset{(2.1)}{0.0157} * DUMDEC - \underset{(4.2)}{0.0000418} * PIGDISP$$

R BAR Squared = 0.803
F Test (4,12) = 17.3
D.W. = 1.86
d.f. = 12
D.V.Mean = 0.313

CLEAN CATTLE PRICE INDEX EQUATION

```
CCP  =  7.05  +  1.16*(MKTCCP + CCPVP)
        (4.6)    (61.0)
```

R BAR Squared = 0.905
F Test (1,18) = 3726
D.W. = 1.88
d.f. = 18
D.V. Mean = 97.3

FAT COW PRICE INDEX

$$\frac{FATCOWP}{RPI} = \underset{(0.6)}{0.0523} - \underset{(2.1)}{0.0027}*TIME\$SA + \underset{(6.9)}{1.14}*\frac{MKTCCP}{RPI} - \underset{(2.3)}{0.000199}*C\$BDISP$$

R BAR Squared = 0.722
F Test (3,26) = 26.1
D.W. = 2.1
d.f. = 26
D.V. Mean = 0.387

CLEAN PIG PRICE EQUATION

$$\frac{PIGP}{RPI} = \underset{(2.7)}{0.355} + \underset{(3.5)}{0.849}*\frac{CCP}{RPI} + \underset{(2.6)}{0.385}*\frac{PIGP.1}{RPI.1} + \underset{(3.2)}{0.0327}*DUMDEC - \underset{(3.1)}{0.0000448}*PIGDISP - \underset{(3.2)}{0.00086}*QTBC$$

R BAR Squared = 0.853
F Test (5,23) = 33
D.W. = 1.83
d.f. = 23
D.V. Mean = 0.424

CULL SOW PRICE INDEX EQUATION

$$\frac{SOWP}{RPI} = \underset{(1.8)}{-0.159} + \underset{(1.5)}{0.210}*\frac{SOWP.1}{RPI.1} + \underset{(3.8)}{0.665}*\frac{PIGP}{RPI} + \underset{(2.3)}{0.512}*\frac{CCP}{RPI}$$

R BAR Squared = 0.592
F Test (3,34) = 18.9
D.W. = 1.22
d.f. = 34
D.V.Mean = 0.416

EGG PRICE INDEX EQUATION

$$\frac{EGGP}{RPI} = \underset{(1.38}{0.594} - \underset{(3.25)}{0.0369}*TIME\$SA + \underset{(1.35)}{2.689}*TPDI/RPI + \underset{(3.81)}{0.538}*EGGP.1/RPI.1$$

R BAR Squared = 0.850
F Test (3,23) = 50.1
D.h. = 1.39
d.f. = 23
D.V.Mean = 0.637

TURKEY PRICE EQUATION

$$\frac{WPTY}{RPI} = \underset{(2.2)}{0.0864} + \underset{(2.5)}{0.776} * \frac{WPTY.1}{RPI} - \underset{(2.7)}{0.516} * \frac{WPTY.2}{RPI.2} + \underset{(3.7)}{0.683} * \frac{WPBC}{RPI}$$

$$- \underset{(2.8)}{4.70E\text{-}6} * CHICKPL\$T.1 + \underset{(3.1)}{0.0215} * DUMDEC$$

R BAR Squared = 0.867
F Test (5,20) = 33.5
D.W. = 2.20
d.f. = 20
D.V.MEAN = 0.22

BROILER PRICE EQUATION

$$\frac{WPBC}{RPI} = \underset{(1.6)}{0.0549} + \underset{(2.8)}{0.383} * \frac{WPBC.1}{RPI} + \underset{(3.8)}{0.191} * \frac{PIGP}{RPI} - \underset{(1.8)}{0.000185} * QTBC$$

R BAR Squared = 0.742
F Test (3,31) = 33.6
D.W. = 1.62
d.f. = 31
D.V.Mean = 0.176

COST per LB OF FINISHED BROILERS

$$COST{:}LB = \underset{(1.3)}{3.38} + \underset{(42.0)}{0.192} * COMPP\$PO + \underset{(2.5)}{3.83} * SD + \underset{(1.7)}{37.8} * MORT - \underset{(2.3)}{1.26} * LIVEW$$

R BAR Squared = 0.998
F Test (4,31) = 3627
D.W. = 1.47
d.f. = 31
D.V. Mean = 14.1

Definition of Variables

WHEATP	= Wheat price index.
PPW	= Policy price of wheat, defined as: alpha*WIP + (1-alpha)*WETP.
alpha	= Dummy variable = 1 in second period of calander year 0.5 in first.
WIP	= Wheat Intervention price.
WETP	= Wheat Effective Threshold price.
CIFW	= Import price of wheat.
POULT$TAB	= Number of birds recorded for the table.
WHEATPROD	= Production of wheat.
BARLEYP	= Price index of barley.
PPB	= Policy price for barley, defined as: alpha*BIP + (1-alpha)*BETP.
BARLEYPROD	= Production of barley.
DUMDEC	= Seasonal dummy, =1 in second period 0 in first.
COMPP$PO	= Price index of compound feed fed to poultry.
DUMWP:RAT	= Dummy variable for the wheat price, as defined in the text.
COMPP$C	= Price index of compound feed fed to cattle.
DUMBP:RAT	= Dummy variable for the barley price, as defined in the text.
MILKOUTPUT	= Milk sales to the MMB.
COMPP$P	= Price index of compound feed fed to pigs.
PIGLSU	= Pig live stock units, as defined as BREEDSOW + GILTSINPIG + BOARS + 0.2*FATPIG.
MILKP	= Milk price paid to wholesale producers.
AVMILKP	= Theoretical value of milk, based on a weighted Average of the price of liquid milk, and policy prices for butter and SMP.
MKTCCP	= Market price received for clean cattle.
RPI	= Retail price index.
CATTGP	= Target price for clean cattle.

SHSLGHT$A = Steers and heifers slaughtered, adjusted for 53 week statistical year.

PIGDISP = Slaughterings of fat pigs.

CCP = Clean cattle price index.

CCPVP = Clean cattle variable premium payment.

FATCOWP = Fat cow price index.

TIME$SA = Time trend.

C$BDISP = Cow and bull slaughterings.

PIGP = Price index of clean pigs.

QTBC = Broiler slaughterings.

SOWP = Cull sow price index.

EGGP = Price index of eggs.

EGGPROD = Output of eggs for human consumption.

WPTY = Price per pound live weight for turkeys.

WPBC = Price per pound live weight for broilers.

CHICKPL$T = Placings of turkey chicks.

COST:LB = Cost per pound of finished broilers.

SD = Stocking density of broilers.

TR = Turn round time for broilers.

MORT = Percentage mortality rate of broilers.

LIVEW = Live weight of broilers at slaughter.

Chapter 10

MINOR CROP AND INPUT EQUATIONS

(M Burton)

Introduction

In this Chapter the results for a number of estimated equations are presented. These cover the minor crops that have not been fully modelled, those inputs, major and minor, that have not been fully modelled, and the miscellaneous elements, such as compensation payments, value of stock changes etc. This fairly large block of equations can be split into two sections. The first contains genuinely minor elements, that would never justify more than a simple ARIMA model or crude linkage equation within a model of UK agriculture designed to operate at the level of the DNIC. The other section contains elements that ideally should receive more attention in their specification and estimation, but which can not at this stage, due to lack of time. Simple equations have therefore been estimated for these elements just in order to close the model, and allow a full simulation.

In most cases, the annual value of the element has been used as the dependant variable in the equation, over the period 1970 to 1983. There has been a simple search for a specification with a high explanatory power, usually involving time trends in a variety of forms. Little justification can be put forward in defence of these equations other than that they have a high explanatory power over the data period.

MINOR OUTPUT EQUATIONS

Value of Beans for Stockfeed, Hay and Dried Grass, Grass and Clover Seed and Fodder and Other Minor Crops.

$$\ln(FODDER) = \underset{(4.74)}{-2.406} + \underset{(12.21)}{2.158 * \ln(TIME\$A)}$$

R BAR Squared = 0.914
F Test (1,13) = 149
D.W. = 1.308
d.f. = 13
D.V. Mean = 3.76

Value of Hops.

$$\ln(HOPS) = \underset{(0.64)}{0.115} + \underset{(14.50)}{0.988 * \ln(HOPS.1)}$$

R BAR Squared = 0.942
F Test (1,12) = 210
D.h. = 1.37
d.f. = 12
D.V. Mean = 2.66

Value of Oilseed Rape.

Some efforts have been made to develop a full model for this sector, but the rapid rise in the area planted over the previous 10 years causes difficulties. Some price response could be detected, but the main factor determining the rise in area was a time trend, and in general the specification was unsatisfactory. The current specification of value alone is therefore probably only a small retrograde step from that specification, and at some point in the near future a more satisfactory model will be developed.

$$Ln(OILSEED) = \underset{(7.11)}{-29.5} - \underset{(2.10)}{0.276*TIME\$A} + \underset{(5.73)}{13.01*LN(TIME\$A)}$$

R BAR Squared = 0.987
F Test (2,12) = 534
D.W. = 1.83
d.f. = 12
D.V. Mean = 3.95

Value of Other Livestock.

$$Ln(OTHERLS) = \underset{(6.99)}{-5.50} - \underset{(9.29)}{0.112*TIME\$A} + \underset{(4.48)}{4.01*Ln(TIME\$A)}$$

R BAR Squared = 0.993
F Test (2,12) = 951
D.W. = 1.49
d.f. = 12
D.V. MEAN = 3.95

Value of Clip Wool.

$$Ln(CLIPWOOL) = \underset{(3.32)}{-1.10} + \underset{(13.01)}{1.503*Ln(TIME\$A)}$$

R BAR Squared = 0.924
F Test (1,13) = 170
D.W. = 0.477
d.f. = 13
D.V. Mean = 3.20

Other Livestock Products

```
Ln(OTHERLSP)  =  -6.86  +  3.23*Ln(TIME$A)
                 (14.0)    (18.9)
```

```
R BAR Squared = 0.962
F Test (1,13) = 360
D.W.          = 1.82
d.f.          = 13
D.V. Mean     = 2.38
```

Value of Total Own Account Capital Formation.

```
OWNAC/CCP$A  =   0.691  +  0.0041*(DH$DEC - DH$DEC.1)
                 (7.81)    (3.10)
```

```
R BAR Squared = 0.380
F Test (1,13) = 9.58
D.W.          = 1.91
d.f.          = 13
D.V. Mean     = 0.693
```

Value of Compensation Payments.

```
Ln(COMPPAY)  =  2.00  +  0.0917*TIME$A
               (5.27)    (4.46)
```

```
R BAR Squared = 0.575
F Test (1,13) = 19.9
D.W.          = 1.02
d.f.          = 13
D.V. Mean     = 3.65
```

Value of Production Grants.

$$\ln(PRODGR) = \underset{(21.4)}{4.35} + \underset{(2.04)}{0.022 * TIME\$A}$$

R BAR Squared = 0.184
F Test (1,13) = 4.16
D.W. = 1.37
d.f. = 13
D.V.Mean = 4.75

Value of Physical Change in Output Stocks and Work in Progress

$$OTPPST/FERTP\$A = \underset{(0.91)}{-0.165} + \underset{(7.21)}{0.00087 * (STDECW+STDECB-STDECW.1-STDECB.1)}$$

R BAR Squared = 0.849
F Test (1,8) = 51.9
D.W. = 2.82
d.f. = 13
D.V. Mean = 0.0581

Value of Intermediate Output: Seed.

This is one of the areas where a more detailed model may be appropriate, but here it is simply linked to purchased seed.

$$IOSEED = \underset{(0.70)}{0.7012} + \underset{(84.7)}{0.466 * SEEDS}$$

R BAR Squared = 0.998
F Test (1,13) = 7186
D.W. = 1.44
d.f. = 13
D.V. Mean = 78.3

Value of Intermediate Output: Feed.

Again, further work would be justified on this area.

```
IOFEED  =  -51.5   +  0.283*FEEDVAL
           (1.85)    (18.76)
```

R BAR Squared = 0.962
F Test (1,13) = 352
D.W. = 0.880
d.f. = 13
D.V. Mean = 425

INPUT EQUATIONS

Value of Purchased Seeds

```
Ln(SEEDS)  =  -6.68  +  5.18*Ln(TIME$A)  -  0.175*TIME$A
              (2.73)    (5.18)               (2.25)
```

R BAR Squared = 0.939
F Test (2,12) = 109
D.W. = 1.06
d.f. = 12
D.V. Mean = 4.98

Value of Livestock (imported and inter-farm expenses)

```
Ln(LIVEST)  =  1.76  +  1.08*Ln(TIME$A)
              (6.08)   (10.78)
```

R BAR Squared = 0.892
F Test (1,13) = 116
D.W. = 2.29
d.f. = 13
D.V. Mean = 4.86

Value of Fertilisers and Lime.

For this important input, a slightly more detailed approach has been used. An index of the fertiliser quantity is generated by dividing the value by a price index of fertiliser. This quantity index was then explained as a function of changes in fertiliser prices, the quantity of cereals produced and a time trend. Although the parameters are significant, and of the expected sign, there is again no knowing if the results are spurious. As it stands, it is a major simplification over what we would expect to determine fertiliser consumption. Earlier, some considerable time was spent on trying to develop a more sophisticated model. This started from the point that useage of fertiliser should be split into that being used for cereals, and that for milk (an aspect that is ignored here). Using survey data on nitrogen usage per hectare by crop type it was possible to aggregate up to an estimate of total useage that was reasonably in line with the DNIC quantity. However, it was not possible to then significantly explain the per hectare usage. Further work is clearly needed in this area. For the moment, the value is simply determined by multiplying the forecast quantity index as modelled below by the price index.

```
FERTQ  =  11.57   -  3.55*FERTP/FERTP.1   +  0.000034*(WPROD+BPROD)
          (7.96)     (3.48)                  (5.21)

                  -  0.3416*TIME$A
                     (6.11)
```

```
R BAR Squared = 0.755
F Test (3,11) = 15.4
D.W.          = 2.43
d.f.          = 11
D.V. Mean     = 6.97
```

Value of Machinery Expenses.

```
Ln(MACHINE)  =  0.261  +  0.520*Ln(TOTOUT)  +  0.0702*TIME$A
                (.30)     (3.83)                (6.11)
```

R BAR Squared = 0.995
F Test (2,11) = 1286
D.W. = 1.33
d.f. = 12
D.V. Mean = 6.04

Value of Miscellaneous Expenditure

```
Ln(MISC)  =  -1.562  +  0.814*Ln(TOTOUT)  +  0.0367*TIME$A
             (1.57)     (5.29)                (1.90)
```

R Bar Squared = 0.993
F Test (2,12) = 1055
D.W. = 1.29
d.f. = 12
D.V. Mean = 6.17

Value of Total Depreciation.

```
Ln(DEPR)  =  -1.180  +  2.66*Ln(TIME$A)
             (4.29)     (27.7)
```

R BAR Squared = 0.982
F Test (1,13) = 770
D.W. = 0.531
d.f. = 13
D.V. Mean = 6.42

Value of Total Farm Maintenance

$$\ln(MAINT) = \underset{(5.73)}{-0.858} + \underset{(38.0)}{1.98*\ln(TIME)}$$

R BAR Squared = 0.990
F Test (1,13) = 1443
D.W. = 1.18
d.f. = 13
D.V. Mean = 4.81

Definition of variables

The dependant variables for each equation should be self explanatory from the equation heading. Other variables are:-

TIME$A = Annual time trend.

DH$DEC = Dairy herd size recorded in December.

STDECW = Stocks of wheat held on-farm at the end of December.

STDECB = Stocks of barley held on-farm at the end of December.

FEEDVAL = Value of all purchased feeds.

FERTP$H = Price index of fertiliser.

WPROD = Production of wheat.

BPROD = Production of barley.

TOTOUT = Value of total output.

Chapter 11

SIMULATION AND POLICY ANALYSIS

(M.P. Burton)

Introduction

When brought together, the sectors reported in the previous chapters comprise a model of some 200 equations. This is using the truncated horticulture model, which deals with the top level allocation only. If the full horticulture model were used then the equation count would rise to nearer 400, which is excessive.

The first stage of the simulation analysis is to see how the full model performs within the data period. In the previous Chapters, sector simulations have been undertaken in isolation, so that the full interaction between the sectors (which occurs via the interdependence within the price systems) can not come into play. When they do within a full simulation, it greatly increases the possibility of the model diverging from the actual time path.

The number of exogenous variables within the system makes it impractical to list them all. However, it is of interest to note that of the 80 exogenous variables, 32 are either weather variables or temporal dummy variables; 9 others are technical coefficients such as mortality rates or dressed carcass weights; 16 are policy variables; 11 are prices or macro economic variables (either from within the agricultural sector, such as fertiliser prices, or without, such as total personal disposable income, the retail prices index etc.). The remaining elements are mostly quantity adjustments which have to be made to variables during the calculation of the value of output (e.g. the estimate of unrecorded pig slaughterings). From this it can be seen that simulations of the full system are almost self-contained, and that with a little further development all of the variables deemed within the agricultural sector and required by the model, will be generated within it.

Within-period Simulation

In Table 11.1 below, the simulated values for a full, dynamic simulation of the model are given, in Table 22 format. The (highlighted) lines denoted by (S) are the simulated values, and the line below (denoted by (A)) are the actual values. The period used is 1978 to 1982. This period is constrained by the availability of the exogenous variables, and it should be possible after identification of the restricting variable(s), to extend the simulation up to a more recent date. There are some problems with simulating cereal values, but these are caused by poor performance of the stocks equations. At the level of total farm crops there is an error of some 7% in the first period, and 10% in the last, but the intervening 3 periods have errors of less than 3%. The horticulture sector tracks well, with errors of less than 5% in all but the last period, and a similar result is true for fat cattle. At the level of total livestock the errors are very small, all being less than 2%, with most substantially less.

The livestock products group performs well, with eggs in 1981 and 1982 being the only exception, this being an unresolved problem area that was noted in Chapter 7. At the level of final output the size of error in all years except 1982 has fallen to a very small level. This may simply be an indication of a cancelling out of earlier errors, but the ability of the model to stay on track, and not deviate over the period, is very encouraging.

The estimate of feedingstuffs is consistently over the actual value, but the size of the error is not large until the final period of the simulation. The remaining inputs have been estimated using the ad hoc equations, but even so, the simulated values are quite good. Although not of interest in itself, this means that the later derivation of net product will not be overly distorted by these elements. In fact, the errors in net product in each year are 2.3%, 6.9%, 5.9%, -1.7%, and -7.4%. These do not appear to be too large, but difficulties may arise in the next phase of the modelling. One of the most important aspects of using the model for policy

Table 11.1
Comparison of Actual and Simulated Values, Output, Input and Net Farm Income, 1978-1982

Calendar Years			1978	1979	1980	1981	1982
Farm Crops:	Wheat	(S)	471	623	724	860	874
		(A)	450	605	786	855	1137
	Barley	(S)	595	642	730	734	858
		(A)	549	557	651	811	894
	Oats Plus	(S)	24	26	25	24	21
		(A)	21	22	26	28	31
Total Cereals		(S)	1090	1290	1480	1620	1755
		(A)	1020	1184	1463	1694	2060
	Potatoes	(S)	277	316	360	408	466
		(A)	260	385	312	392	451
	Sugar Beet	(S)	162	169	205	194	252
		(A)	159	206	195	192	252
	Hops	(S)	12	13	14	15	17
		(A)	13	17	23	25	28
	Oil Seed	(S)	34	50	72	100	135
		(A)	28	43	69	87	157
	Other	(S)	52	58	64	71	78
	Fodder	(A)	45	61	67	71	69
Total Farm Crops		(S)	1627	1896	2195	2409	2704
		(A)	1526	1895	2128	2461	3020
Horticulture	Vegetables	(S)	475	552	602	620	647
		(A)	460	536	560	584	596
	Fruit	(S)	168	159	186	197	225
		(A)	152	158	170	187	212
Total Horticulture		(S)	785	872	970	1009	1081
		(A)	750	854	913	962	1012
Livestock:	Fat Cattle	(S)	1244	1367	1472	1567	1758
		(A)	1258	1420	1500	1600	1666
	Fat Sheep	(S)	280	324	391	430	528
		(A)	300	319	405	465	515
	Fat Pigs	(S)	679	763	829	860	851
		(A)	689	744	790	862	925

Table 11.1 cont.			1978	1979	1980	1981	1982
	Poultry	(S)	427	468	532	587	598
		(A)	444	488	508	515	604
	Other Livestock	(S)	65	71	77	83	89
		(A)	63	71	85	87	91
Total Livestock		(S)	2694	2994	3301	3527	3823
		(A)	2754	3043	3287	3528	3801
Livestock Prods.	Milk	(S)	1582	1694	1880	2055	2300
		(A)	1591	1730	1925	2064	2341
	Milk Products	(S)	27	30	34	37	42
		(A)	29	34	35	37	43
	Eggs	(S)	414	462	504	477	427
		(A)	400	462	489	522	529
	Clip Wool	(S)	28	30	32	35	37
		(A)	33	35	36	35	34
	Other Livestock	(S)	14	17	20	23	26
		(A)	12	16	16	24	26
Total Livestock Products		(S)	2065	2233	2470	2626	2833
		(A)	2065	2276	2500	2682	2972
Total Own Account Capital Formation		(S)	54	62	50	82	97
		(A)	65	24	47	94	136
TOTAL OUTPUT		(S)	7227	8058	8986	9654	10593
		(A)	7159	8092	8875	9727	10942
Total Compensation Payments		(S)	42	46	51	56	61
		(A)	31	29	33	60	62
Total Production Grants		(S)	118	121	124	126	129
		(A)	90	84	130	141	150
TOTAL RECEIPTS		(S)	7387	8225	9161	9836	10730
		(A)	7281	8205	9037	9928	11154
Total Value of Physical Change		(S)	-34	28	-68	46	-79
		(A)	15	-6	14	-74	2
GROSS OUTPUT		(S)	7353	8253	9093	9883	10651
		(A)	7295	8199	9051	9854	11156

Table 11.1 cont.

		1978	1979	1980	1981	1982
Intermediate output: Feed	(S)	473	549	568	632	636
	(A)	393	539	586	564	728
Seed	(S)	88	97	104	112	118
	(A)	91	9	94	102	111
FINAL OUTPUT	(S)	6791	7607	8421	9139	9896
	(A)	6811	7561	8371	9188	10317
INPUT						
Feedingstuffs	(S)	1854	2124	2190	2415	2430
	(A)	1774	2089	2187	2282	2612
Seeds	(S)	188	206	223	238	252
	(A)	193	211	200	217	236
Livestock	(S)	141	149	157	166	174
	(A)	175	137	151	154	171
Fertilisers and Lime	(S)	513	587	635	732	772
	(A)	491	548	651	762	777
Machinery	(S)	500	568	645	718	806
	(A)	493	593	668	743	833
Total Farm Maintenance	(S)	145	161	177	194	212
	(A)	147	166	179	190	215
Miscellaneous Expenditure	(S)	585	663	752	827	922
	(A)	584	709	784	846	959
TOTAL EXPENDITURE	(S)	3927	4458	4779	5290	5567
	(A)	3857	4453	4820	5194	5803
Total Stock Change	(S)	0	0	0	0	0
Due to Volume	(A)	22	-24	23	-56	-22
GROSS INPUT	(S)	3927	4458	4779	5290	5567
	(A)	3879	4429	4797	5138	5781
NET INPUT	(S)	3365	3812	4106	4546	4813
	(A)	3395	3881	4117	4472	4942
GROSS PRODUCT	(S)	3426	3795	4314	4593	5083
	(A)	3416	3680	4254	4716	5375
Total Depreciation	(S)	772	885	1007	1140	1283
	(A)	821	957	1133	1203	1269
NET PRODUCT	(S)	2654	2910	3307	3453	3800
	(A)	2595	2723	3121	3513	4106

anaysis is the implications of policy changes on farm income. As has been noted earlier, it has not been possible to extend the model (at the current time) in order to achieve this, but farm income is essentialy a residual, taking what ever remains of net product after labour, interest and net rent has been paid. Farm income as a proportion of net product has been on a downward trend over the past decade and it currently accounts for approximately 25-30% of net product. This means that there is a strong possibility that percentage errors in net product will become magnified when translated into farm income. Given that farm income is determined as a residual, and a small one compared with the magnitude of other values in the calculation (e.g 15% of gross output), this has always been foreseen as a problem. Only after the model has been extended will it become apparent if it is a serious one.

The second stage of the analysis is to conduct some trial policy simulations Two have been chosen: the impact of a 10% cut in milk quota, and a 10% reduction in the cereal policy prices. These scenarios were chosen as they have some current interest, but they also provide some insight into the way that the different sectors of the model interact.

Simulation of a 10% cut in Milk Quota

Table 11.2 below gives the simulation results for a 10% cut in milk quota, for the 5 year period 1987 to 1991. Two sets of values are given, "Base" values (denoted by (B)) and "Jump" values (denoted by (J)). Taking the base simulation first, it is important to note that the simulation is outside the data period, and that therefore there have to be some assumptions made about the values of the exogenous variables. For convenience, all exogenous variables except the seasonal dummy and the milk quota level are held constant at their 1982 period 2 values, despite the fact that there may be more recent observations on some of them. As quotas were not in place in 1982, the quota is extrapolated on the basis of its 1985 value. This means that the values generated for 1987 should not be considered as forecasts of the actual values for that year, as all inflationary elements (i.e RPI and policy price rises) have been constrained, and effectivly technical change (represented by time) has been halted. As we are concerned with a comparison of alternative policies these factors do not affect us, but if one wanted to make a genuine forecast of future values for the various elements of the table, then one would supply "best guesses" for the values of the exogenous variables. The model has then been simulated over the period 1978 to 1991, and the table reports the final 5 years of this period. It should be noted that half way through the period the milk sector switches from an unconstrained form to the quota form (see Chapter 4 for details) so that in the reported period we are operating under a quota regime.

The "Jump" values are calculated be re-running this simulation, but in 1987 reducing the size of the quota by 10%. In this way, the table can be used to indicate the impact of the quota reduction on the various sectors of the model. Note that as the "base" run has not reached its equilibrium by 1991, one cannot compare changes across time <u>within</u> the "Jump" simulation, but only between "Base" and "Jump" at any point in time.

The first point to note is that the reduction in quota has no impact on any of the crop sectors. One would have thought that there would be some substitution into cereals as a result of decline in quota, and if it had been possible to introduce milk returns into the total cereal area equation, then this would have occured. However, as was noted in Chapter 1, no competing livestock activities were found to be significant determinants of the cereals area.

In the livestock products section, the largest impact is the 10% reduction in the value of milk. As milk prices are policy determined this follows directly from the quota cut. There are no other impacts on other product groups, but there are changes in the livestock sectors. The value of fat cattle rises, but only slightly. The underlying changes in the stock numbers are as follows. As a result of the

Table 11.2
Simulation of a 10% cut in Milk Quota, on Output, Input and Farm Income

Calendar Years			1987	1988	1989	1990	1991
Farm Crops:	Wheat	(B)	925	935	943	950	956
		(J)	925	935	943	950	956
	Barley	(B)	707	701	696	689	687
		(J)	707	701	696	689	687
	Oats Plus	(B)	20	20	20	20	20
		(J)	20	20	20	20	20
Total Cereals		(B)	1652	1656	1660	1662	1665
		(J)	1652	1656	1660	1662	1665
	Potatoes	(B)	453	453	453	453	453
		(J)	453	453	453	453	453
	Sugar Beet	(B)	277	276	276	275	275
		(J)	277	276	276	275	275
	Hops	(B)	25	27	29	31	34
		(J)	25	27	29	31	34
	Oil Seed	(B)	178	178	178	178	178
		(J)	178	178	178	178	178
	Other	(B)	86	86	86	86	86
	Fodder	(J)	86	86	86	86	86
Total Farm Crops		(B)	2671	2677	2682	2687	2692
		(J)	2671	2677	2682	2687	2692
Horticulture	Vegetables	(B)	629	630	631	632	632
		(J)	629	630	631	632	632
	Fruit	(B)	213	213	212	212	212
		(J)	213	213	212	212	212
Total Horticulture		(B)	1049	1050	1050	1051	1051
		(J)	1049	1050	1050	1051	1051
Livestock:	Fat Cattle	(B)	1762	1761	1764	1768	1769
		(J)	1768	1764	1766	1770	1771
	Fat Sheep	(B)	557	563	568	574	577
		(J)	557	563	568	573	577

Table 11.2 cont.			1987	1988	1989	1990	1991
	Fat Pigs	(B)	697	687	683	684	684
		(J)	697	687	683	683	681
	Poultry	(B)	523	519	518	519	520
		(J)	523	519	518	519	519
	Other Livestock	(B)	94	94	94	94	94
		(J)	94	94	94	94	94
Total Livestock		(B)	3634	3625	2627	3639	3645
		(J)	3640	3627	3630	3640	3642
Livestock Prods.	Milk	(B)	2005	2005	2005	2005	2005
		(J)	1803	1803	1803	1803	1803
	Milk Products	(B)	42	42	42	42	42
		(J)	42	42	42	42	42
	Eggs	(B)	235	232	231	230	229
		(J)	235	232	231	230	229
	Clip Wool	(B)	40	40	40	40	40
		(J)	40	40	40	40	40
	Other Livestock	(B)	30	30	30	30	30
		(J)	30	30	30	30	30
Total Livestock Products		(B)	2353	2349	2348	2347	2346
		(J)	2150	2147	2146	2145	2144
Total Own Account Capital Formation		(B)	72	77	82	78	80
		(J)	46	57	76	71	74
Total Output		(B)	9778	9778	9789	9802	9813
		(J)	9556	9558	9583	9594	9603
Total Compensation Payments		(B)	67	67	67	67	67
		(J)	67	67	67	67	67
Total Production Grants		(B)	132	132	132	132	132
		(J)	132	132	132	132	132
TOTAL RECEIPTS		(B)	9977	9977	9988	10001	10013
		(J)	9755	9757	9783	9793	9802
Total Value of Physical Change		(B)	-19	-19	-19	-18	-18
		(J)	-19	-19	-19	-18	-18
GROSS OUTPUT		(B)	9958	9958	9970	9982	9994
		(J)	9736	9738	9764	9775	9784

Table 11.2 cont.		1987	1988	1989	1990	1991
Intermediate output: Feed	(B)	495	494	493	492	492
	(J)	466	466	463	463	463
Seed	(B)	123	123	123	123	123
	(J)	123	123	123	123	123
FINAL OUTPUT	(B)	9340	9341	9354	9367	9379
	(J)	9147	9151	9178	9189	9197
INPUT						
Feedingstuffs	(B)	1931	1928	1922	1921	1922
	(J)	1828	1821	1817	1816	1818
Seeds	(B)	263	263	263	263	263
	(J)	263	263	263	263	263
Livestock	(B)	182	182	182	182	182
	(J)	182	182	182	182	182
Fertilisers and Lime	(B)	750	751	752	752	753
	(J)	750	751	752	752	753
Machinery	(B)	831	831	832	832	833
	(J)	822	822	823	823	823
Total Farm Maintenance	(B)	231	231	231	231	231
	(J)	231	231	231	231	231
Miscellaneous Expenditure	(B)	899	899	900	901	902
	(J)	883	883	885	886	886
TOTAL EXPENDITURE	(B)	5088	5086	5082	5083	5086
	(J)	4959	4953	4953	4954	4957
Total Stock Change	(B)	0	0	0	0	0
Due to Volume	(J)	0	0	0	0	0
GROSS INPUT	(B)	5088	5086	5082	5083	5086
	(J)	4959	4953	4953	4954	4957
NET INPUT	(B)	4470	4468	4467	4468	4470
	(J)	4369	4365	4366	4366	4371
GROSS PRODUCT	(B)	4870	4872	4887	4899	4908
	(J)	4778	4786	4811	4821	4827
Total Depreciation	(B)	1436	1436	1436	1436	1436
	(J)	1436	1436	1436	1436	1436
NET PRODUCT	(B)	3433	3436	3451	3463	3472
	(J)	3341	3349	3375	3385	3390

decline in the quota, there is an initial decline in the dairy herd of 1.5%, and a decline of some 12% in milk yields. This is needed to overcome the high initial herd size, in order to reduce milk output sufficiently. By the end of the 1991 the dairy herd has fallen by 4%, and milk yield by 6%. This decline in the milk yield results in an increase in the beef sector, with beef herd numbers growing by 6.5% by 1991. However, steer and heifer slaughtering have risen by barely 0.5%, as a large proportion of the animals come from the dairy herd. There are minor effects in the pig sector, because of the linkage between beef and pig market prices. As a result of the slight decline in pig prices, one sees the start of the pig cycle, with numbers slaughtered falling also, giving the decline in pig value. In order to say whether this would hold in the long run, one would have to allow the model to run to its equilibrium. A similar, but smaller, effect is observed in the poultry sector. The change in gross output as a result of these changes is -2%.

On the input side, the only major effect is on feedstuffs, which comes directly from the change in cattle compound feed use as a result of the decline in output. The quantity of cattle compound feed declines by some 12%, which, with the 2% fall in the price of compound feed that this in turn induces, leads to a 5% fall in the value of feed purchased in 1991, compared with the base run, and a 2.5% fall in gross input

These combined effects give a 2.7% fall in net product in the first year, falling to a 2.4% decline in the 5th.

Simulation of a 10% Cut in Cereal Policy Prices

The analysis of a 10% cut in the cereal policy prices follows the same path. The base run is initiated, and then in 1987 a 10% reduction in the intervention and threshold prices of wheat and barley are introduced. The changes in the values that this causes are reported in Table 11.3 below. The effects are more wide ranging than in the previous case, as the change in price will affect the cereals sector directly, and also the livestock sectors via the changes in feed prices.

Due to the planting lag, there is no cereal area response in the first period, so the drop in value is caused entirly by the fall in prices recieved. The imperfect transmission of the policy price, there is a 6.2% and 6.9% drop in the value of wheat and barley respectively in the first year. However, by 1991, when the area of each has fallen by 1.5% and 1.2% the decline has extended to -8.8% and -8.3%. The horticultural sector sees some increase in value, as area expands by some 3% but the increase in value of only 1.5% reflects the impact this expansion in output will have on the unsupported prices of the sector.

In the livestock sectors the effects are less obvious. The decline in wheat prices leads to a decline in compound feed prices, of around 7% overall. This in turn leads to expansions in all feed using sectors (apart from milk) i.e by 1991 there is a 1% increase in pigs slaughtered, 1% increase in turkey chick placings and a 4% increase in steer and heifer slaughterings. These in turn lead to declines in the market prices recieved for the products, 4% for turkeys, 10% for pigs and 4% for cattle. The latter translates through to producer prices because the maximum payable variable premium is exceeded, and therefore the support system no longer gives any protection from declines in market prices. These changes all cause the value of total output to fall. This position is not sustainable for pigs, as the fall in product price is greater than the fall in feed price, implying that the relative prices have moved against the sector, but presumably they are approaching the peak of a cycle, and would now start to contract again. An exception to this sequence is the broiler sector, for which the model projects a small increase in output in 1987, but this caused an almost exactly offsetting decline in prices, so that the sector did not purturb from the base run to any noticable degree. The impact on the milk sector is interesting. Clearly it does not affect total milk output, which is constrained by the quota, but it does affect the way the milk is produced, as there is an increase of 3% in cow

Table 11.3
Simulation of a 10% Cut in Cereal Policy Prices on Output, Input and Farming Income

Calender Years			1987	1988	1989	1990	1991
Farm Crops:	Wheat	(B)	925	935	943	950	956
		(J)	868	864	869	871	872
	Barley	(B)	707	701	696	689	687
		(J)	658	647	642	635	630
	Oats Plus	(B)	20	20	20	20	20
		(J)	20	20	22	23	24
Total Cereals		(B)	1652	1656	1660	1662	1665
		(J)	1546	1532	1533	1529	1526
	Potatoes	(B)	453	453	453	453	453
		(J)	453	452	449	447	447
	Sugar Beet	(B)	277	276	276	275	275
		(J)	277	278	278	278	278
	Hops	(B)	25	27	29	31	34
		(J)	25	27	29	31	34
	Oil Seed	(B)	178	178	178	178	178
		(J)	178	178	178	178	178
	Other	(B)	86	86	86	86	86
	Fodder	(J)	86	86	86	86	86
Total Farm Crops		(B)	2671	2677	2682	2687	2692
		(J)	2566	2553	2550	2550	2549
Horticulture	Vegetables	(B)	629	630	631	632	632
		(J)	629	631	637	642	646
	Fruit	(B)	213	213	212	212	212
		(J)	213	213	212	212	212
Total Horticulture		(B)	1049	1050	1050	1051	1051
		(J)	1049	1051	1058	1064	1068
Livestock:	Fat Cattle	(B)	1762	1761	1764	1768	1769
		(J)	1757	1742	1738	1738	1737
	Fat Sheep	(B)	557	563	568	574	577
		(J)	557	563	568	571	574

Table 11.3 cont.			1987	1988	1989	1990	1991
	Fat Pigs	(B)	697	687	683	684	684
		(J)	694	684	678	662	647
	Poultry	(B)	523	519	518	519	520
		(J)	521	514	510	503	498
	Other Livestock	(B)	94	94	94	94	94
		(J)	94	94	94	94	94
Total Livestock		(B)	3634	3625	2627	3639	3645
		(J)	3624	3597	3588	3567	3550
Livestock Prods.	Milk	(B)	2005	2005	2005	2005	2005
		(J)	2005	2005	2005	2005	2005
	Milk Products	(B)	42	42	42	42	42
		(J)	42	42	42	42	42
	Eggs	(B)	235	232	231	230	229
		(J)	235	233	232	232	232
	Clip Wool	(B)	40	40	40	40	40
		(J)	40	40	40	40	40
	Other Livestock	(B)	30	30	30	30	30
		(J)	30	30	30	30	30
Total Livestock Products		(B)	2353	2349	2348	2347	2346
		(J)	2353	2350	2349	2349	2349
Total Own Account Capital Formation		(B)	72	77	82	78	80
		(J)	74	93	98	87	84
TOTAL OUTPUT		(B)	9778	9778	9789	9802	9813
		(J)	9666	9644	9647	9619	9601
Total Compensation Payments		(B)	67	67	67	67	67
		(J)	67	67	67	67	67
Total Production Grants		(B)	132	132	132	132	132
		(J)	132	132	132	132	132
TOTAL RECEIPTS		(B)	9977	9977	9988	10001	10013
		(J)	9865	9843	9846	9819	9800
Total Value of Physical Change		(B)	-19	-19	-19	-18	-18
		(J)	-19	-20	-24	-23	-22
GROSS OUTPUT		(B)	9958	9958	9970	9982	9994
		(J)	9846	9823	9822	9796	9778

Table 11.3 cont.		1987	1988	1989	1990	1991
Intermediate output: Feed	(B)	495	494	493	492	492
	(J)	480	462	460	459	458
Seed	(B)	123	123	123	123	123
	(J)	123	123	123	123	123
FINAL OUTPUT	(B)	9340	9341	9354	9367	9379
	(J)	9242	9239	9239	9213	9197
INPUT						
Feedingstuffs	(B)	1931	1928	1922	1921	1922
	(J)	1879	1813	1807	1805	1799
Seeds	(B)	263	263	263	263	263
	(J)	263	263	263	263	263
Livestock	(B)	182	182	182	182	182
	(J)	182	182	182	182	182
Fertilizers and Lime	(B)	750	751	752	752	753
	(J)	750	750	747	745	743
Machinery	(B)	831	831	832	832	833
	(J)	826	825	826	824	823
Total Farm Maintenance	(B)	231	231	231	231	231
	(J)	231	231	231	231	231
Miscellaneous Expenditure	(B)	899	899	900	901	902
	(J)	891	889	889	887	886
TOTAL EXPENDITURE	(B)	5088	5086	5082	5083	5086
	(J)	5022	4954	4945	4938	4927
Total Stock Change	(B)	0	0	0	0	0
Due to Volume	(J)	0	0	0	0	0
GROSS INPUT	(B)	5088	5086	5082	5083	5086
	(J)	5022	4954	4945	4938	4927
NET INPUT	(B)	4470	4468	4467	4468	4470
	(J)	4419	4369	4362	4355	4346
GROSS PRODUCT	(B)	4870	4872	4887	4899	4908
	(J)	4824	4870	4877	4858	4851
Total Depreciation	(B)	1436	1436	1436	1436	1436
	(J)	1436	1436	1436	1436	1436
NET PRODUCT	(B)	3433	3436	3451	3463	3472
	(J)	3387	3433	3440	3421	3414

numbers (and an offsetting movement in yield). The cause of this is the method of generating the dairy herd size under quota. A decline in feed prices would normally encourage an expansion in herd size, but if they did this currently they would have to reduce yield in order to remain within quota. This decline in yield would normally cause a reduction in herd numbers, and so the process continues untill a new equilibrium combination of herd size and yield is found, which will in general be at a higher herd size than before. The counter-intuitive aspect of the result is that as milk yield per cow falls, for a given national output of milk, compound feed use falls, which it does in the simulation by 1%. Thus the compound feed use falls as its price falls. Whether this is a valid result for the opperation of a dairy herd under quotas, or a quirk of the model, remains unclear.

The major impact on the input side is the reduction in the value of feedingstuffs (6.5% by 1991). This is caused by the reduction in price as well as the reduction in quantity used in the milk sector, as noted above, but will have been offset slightly by the increases caused by the increases in activity in the other livestock sectors. The combination of the changes in output and input values give an overall change in net product of -1.3%, 0%, -0.3%, -1.2% and -1.7% for each year.

These two, illustrative, simulations indicate the value of such a model as a tool for policy analysis. Not only can it give guidence on the overall impact of policy cahnges on agriculture as a whole, but one can also identify the changes that are occuring in individual sectors, and the interlinkages between sectors. It can highlight possibly negative implictions for a sector that may appear to be quite independant of a proposed policy change, and it provides a systematic method of evaluating alternative policies. The model could also be used as a short term forecasting tool, given that it operates with such a small set of exogenous variables. It also provides a powerful basis for continuing research, with major studies outside the narrow scope of the DNIC already being implimented, and further enhancements of the model, in scope and application, in view.

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