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Cereals Area Supply Response in the U.K.:

The Effects of CAP Reform

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Objective Analysis
for Informed
Decision Making

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Introduction

Over the period 1975-1995, in England, where most cereals production occurs in the UK, land planted to wheat expanded by about 72 percent (from just over one million hectares to 1.73 million hectares) while land planted to barley decreased by about 54 percent (from about 1.83 million hectares to about 0.84 million hectares). This paper examines the causes of these changes and also investigates the consequences for the sector of the recent 1992 CAP reforms.

The study utilizes time series-cross section data on wheat and barley planting decisions to estimate single equation econometric acreage supply response models for wheat and barley production in England over the period 1975-1995.[1] The results indicate that in the U.K. wheat acreage in particular has been positively related to changes in the price of wheat relative to the price of barley and to changes in wheat yields relative to barley yields, although, as Just has suggested, the acreage supply response elasticities for changes in prices and yields are different. The evidence indicates that the own price elasticity for wheat and the cross price elasticity for wheat with respect to barley are modest and quite similar in absolute size. Thus the relative price effects of the 1992 CAP reforms, which reduced intervention prices for wheat and barley by the same proportions, had relatively little effect on cereals planting decisions. In addition, dummy variables were used to account for the effects of the 1992 CAP reform set aside program.

The evidence from this study suggests that all set aside requirements were satisfied by taking land out of barley production rather than wheat production. Thus the evidence presented here indicates that the effects of CAP reforms on the area planted to wheat were negligible. This suggested that in years in which growing conditions and yields are normal UK wheat production levels are likely to be similar to the levels that obtained in the early 1990s. If this is the case not only for the UK but for other major EU grain producing regions then, over the next few years, the EU is going to have problems meeting its obligations under the 1994 GATT agreement to reduce subsidized exports by at least 22 percent by volume.

The EU Cereals Common Agricultural Policy

Most of the essential elements of the cereals CAP in the EU are well known and have been in place since its implementation in 1967. Cereals producers are guaranteed a minimum price for their products through intervention prices. To prevent imports from reducing EU market prices below target levels, a threshold price is established. Variable import levies, set equal to the difference between the threshold price and the world market price, have been imposed on imports to prevent imports from reducing domestic prices below target levels. Thus the two key policy prices for cereals produces have been threshold prices and intervention prices.

Data on threshold and intervention prices for the period 1975-1995 indicate that the ratio of the threshold price to the intervention price increased substantially during the 1980's. Thus the cost of flour from imported hard wheat increased more rapidly than the cost of flour from domestically produced medium-protein wheat fortified with gluten and may have increased UK demand for flour produced from domestic medium protein varieties of wheat (Leuck, Blaxter and Robertson). The ratio of the threshold price to the intervention price may therefore be an important explanatory variable in an econometric model of UK wheat planting decisions.

The system of threshold and intervention prices has been in place since the inception of the CAP. Paid set aside programs are a more recent innovation. The first, introduced in 1988, was voluntary and required participants to set aside 20 percent of all arable land (including cereals and other corps) in return for compensatory payments. Under the 1992 MacSharry CAP reforms, the set aside program became (in effect) mandatory and was targeted towards more specific crops (cereals, oil seeds, and other protein crops). Under the new program farmers either set aside 15 percent of their base area on a rotational basis or 20 percent of their base area on a non-rotational basis (USDA, 1993-1994). Thus the 1992 set aside program is more onerous that the 1988 program and in the econometric models presented below the effects of the 1988 and 1992 set aside programs are examined separately.

The Economics of Agricultural Supply Response

General theoretical considerations suggest[2] that land use equations for each crop in each region should be specified as follows:

$$A_{i,j} = f\,(E(P),\ E(Y_j),\ E(\Sigma_P),\ E(\Sigma_Y),\ G,\ W,\ \epsilon_{i,j}) \qquad (1)$$

where $A_{i,j}$ denotes land area planted to the i'th crop in region j, P is a 1 by k vector of output prices, W is a 1 by m vector of input prices, Y_j is a 1 by k vector of yields, Σ_P is a vector of price variances, Σ_y is a vector of yield variances, G is a vector of variables measuring the effects of government programs, E(*) is the expectations operator and ϵ_{ij} denotes the error term for crop i in region j.

Equation (1) assumes that input prices and government programs are known with certainty at the time of planting but that expectations have to be formed about output prices, yields, and their variances. The structure of equation (1) implies that separate models should be estimated for each region. However, here it is assumed that across regions elasticities associated with explanatory variables are identical although fixed effects and the structure of the error term may be different. Thus only one equation is estimated for each commodity. This approach imposes restrictions on the structure of the models but those restrictions provide a substantial increase in degrees of freedom.[3]

Expectations about future events play a crucial role in farmers' land use decisions because of the lags between planting, harvesting and marketing agricultural commodities. Previous studies have assumed that farmers solve their yield expectations problems either by assuming that crop yields in year t will be identical to realized yields in t-1 (Colman, 1970; Bewley, Colman and Young), extrapolating from linear time trend models or from models that are linear in time and variable input use (Oury). In this study, nonlinear yield trend models were estimated. The nonlinear model which performed best in all but once region was specified as follows:

$$Y_{i,j,t} = \beta_{i,j,0} + \beta_{i,j,1} T^{\gamma_{i,j,t}} + \epsilon_{i,j,t} \qquad (2)$$

This function collapses to a simple linear trend model if $\gamma = 1$. The hypothesis that $\gamma \geq 1$ was rejected for al eight regions at the one percent level.[4]

Output price expectations are also important in agricultural supply response models. Most previous studies of cereals supply response in the UK and the EU have assumed that farmers either use naive price forecasts in which decisions are based on the previous year's prices (Colman, 1970; Colman, Bewley and Young; Schiff; Oury), prices in the previous two years (Meilke and de Gorter), or a simple weighted average of the past three years (Oury).[5]

This study considered five alternative potential price expectations models for wheat and barley prices. These included (1) ARIMA time series models estimated using data on quarterly average spot market prices obtained from the Home Grown Cereals Authority; (2) a reduced form price forecast model estimated with annual average market price data; (3) a naive market price forecast model in which the expected price is the realized price in the previous year; (4) a naive policy price forecast model in which the expected producer price is the previous year's intervention price; and (5) a combined naive market/policy price forecast model in which the expected price is the higher of the annual average market price and the previous year's intervention price. Comparisons of the five alternative price expectations models were made using representative wheat and barley acreage supply response models. The results indicated that, in terms of the explanatory power of the models and the estimated coefficients associated with relative price variables, the performance of the ARIMA price forecast models was most satisfactory.

Equation 1 also indicates that producers take risk into account in making land use decisions. Here it is assumed that farmers are concerned with crop revenue variance. Following Massow and Weersink, if prices and yields are assumed to be independent, then the variance of revenue for the i'th crop in the j'th region in year t, $\sigma^2_{P_{i,t}Y_{i,j,t}}$ is simply:

$$\sigma^2_{P_{i,t}Y_{i,j,t}} = E(P_{i,t})^2\sigma^2_{Y_{i,j,t}} + E(Y_{i,j,t})^2\sigma^2_{P_{i,t}} + \sigma^2_{P_{i,t}}\sigma^2_{Y_{i,j,t}} \quad (3)$$

where $\sigma^2_{Yi,j,t}$ is the variance of yields for the i'th crop in the j'th region and $\sigma^2_{P,i,t}$ is the variance of the i'th crop's price in year t. Estimates of variances of yields and prices (RISKI) were obtained using the yields and ARIMA price forecast models described above by calculating three year weighted averages of squared deviations of actual realizations from forecasted values for each variable where the declining weights were 0.5, 0.333 and 0.166.

Input prices are potentially important in agricultural supply response decisions. Previous studies have found little evidence of these effects. In this study, data on annual average fertilizer and machinery prices were obtained from MAFF for the estimation period. However, as in other studies, these variables were found to have no significant effects on wheat and barley land use decisions in the UK and, therefore, are not considered further. Government programs that affect land use and other aspects of the farmer's production decision, including variety selection, may also have impacts on land use decisions. The two major European Union set aside programs implemented during the late 1980's and 1990's were described in the previous section. Separate dummy variables for the periods 1989-92 (SET89) and 1993-95 (SET93) are used to capture the potential effects of these programs on land use decisions. In addition, as noted above, increases in the ratio of the threshold to the intervention price for wheat during the 1980's may have increased returns to producers of domestically produced medium (bread making) quality wheat. To account for these potential effects, the ratio of the threshold price to the intervention price for wheat in the year prior to planting, WTHINL was included in the empirical analysis.

Expected output prices, yields and variances of revenues for individual crops and other enterprises involving land use are important explanatory variables in land use decisions. In addition to wheat and barley, oats are also a fairly important as a cereals crop in the UK. Thus oat prices were also included in the analysis.[6] Other potential competing enterprises include dairy cow operations and other livestock (cattle for beef and sheep). Data were obtained on milk prices and livestock prices. However, when included in estimation models, these variables had no effects and, therefore, also are not considered further here.

The estimation equations described below therefore have the following general form:

$$A_{i,j,t} = F(\mathbf{PJI}_t, YJI_{j,t}, RISKI_t, WTHINL_t, SET89_t, SET93_t, \mathbf{REGION}_t, \epsilon_{j,t}), \quad (4)$$

where PJI_t is a vector of relative expected output prices, where J denotes the competing commodities and I denotes the commodity of interest. Similarly, $YJI_{j,t}$ is the ratio of the expected yield of commodity J to commodity I in region j. **REGION** $_t$ is a vector of regional dummy variables and $\epsilon_{i,t}$ denotes the error term. Note that, given the definitions of the relative price and yield variables, the coefficients for these variables are expected to be negative. A detailed list of explanatory variables is provided in Table 1.

Estimation Procedures and Results

All models are estimated in double log form[7] with the TCSCREG procedure in SAS using the Parks method which accounts for cross section (regional) effects through a fixed effects approach and permits a first-order auto-regressive structure in the error term for each region. Thus the assumed error structure is;

$$\epsilon_{i,j,t} = \rho_{i,j} \, \epsilon_{i,j,t-1} + u_{i,j,t} , \qquad (5)$$

where $\rho_{i,j}$ is the first order correlation coefficient and $u_{i,t}$ is the uncorrelated error term for the j'th region. A two stage procedure is used to estimate the covariance matrix leading to estimation of model parameters by generalized least squares.

Table 2 presents parameters estimate for representative models of wheat and barley area supply response. In the wheat models, in addition to regional and set aside dummy variables, the explanatory variables also include the ratios of the expected prices of barley and oats to the expected price of wheat (PBW and POW), the ratio of the expected barley yield to the expected wheat yield,[8] the expected variance of wheat returns, RISKW, and the proportional difference between the wheat threshold and intervention prices, WTHINL. Similar explanatory variables were also included in the barley equation, the only difference being that relative price, yield and risk variables are defined with values for barley in the denominator.

In the wheat equation the coefficient for PBW, the barley/wheat expected relative price variable, is negative, as expected, and significant at the 5 percent level. The coefficient for YBW, the barley/wheat expected relative yield variable, also is negative, as expected, and significant at the 1 percent level. In the barley model, the relative price variable PWB is negative (as expected) but not significant. In contrast, the yield variable, YWB, is negative (as expected) and significant at the 10 percent level.

In the wheat model, the coefficient for POW, the oats/wheat expected relative price variable, has the wrong sign but is insignificant. These findings suggest that oats and wheat do not compete for land at the margin, in contrast to barley and wheat. However, in the barley models, the coefficient for POB, the oats/barley relative price variable, is negative (as expected) and significant at the 10 percent level. In England, farmers appear to shift land between barley and oats but do not between wheat and oats in response to changes in the relative prices.

With the exception of the price of oats in the wheat equation, own and cross-price elasticities have expected signs. In both cases, the estimated own-price elasticities are relatively small (+0.33 for wheat and +0.24 for barley) and much smaller than the estimated own-yield elasticities (+2.69 for wheat and +0.39 for barley). These findings indicate that Just's suggestion that price and yield enter as separate variables in land use models may be important. It should be noted that the estimated cross price elasticities are relatively small, in no case exceeding -0.49 (the estimated elasticity for the price of barley with respect to wheat).

These results suggest that the intervention price reductions for cereals crops implemented under the 1992 CAP reform may not have had very substantial effects on land allocated to wheat production. There are three reasons for this conclusion. First, for wheat the estimated own price elasticity of +0.33 is relatively small. Thus, if the substantial CAP Reform cut of 33 percent in the wheat intervention price resulted in an equivalent reduction in wheat prices, wheat acreage would decline only by about 10 percent. Second, however, as Colman (1985) has noted, there is imperfect transmission of policy prices to market prices. Third, similar percentage cuts were implemented in wheat, barley and oats intervention prices. Thus cross-price effects have largely offset any own price effects both for wheat and for barley.

The set aside components of the CAP reforms of the 1980s and 1990s may have been more important for total cereals production. However, in the wheat model the coefficient for the variable SET89 are positive and significant at the 1 percent level. Thus wheat acreage increased during the period 1989-1992. In contrast, the coefficients for SET89 in the barley model is negative and significant. Moreover, the joint effects on total acreage planted to wheat and barley are negative. The variable SET93 accounts for the effects of the more stringent and, effectively, compulsory set-aside program introduced under the 1992 CAP reform. In the wheat model, the coefficient for this variable is negative but small and not statistically significant. In the barley model, the coefficient for SET93 is negative and about twice as large as the coefficient for the SET89 variable.

Given the double log specification of the models, the set aside dummy variable coefficients indicate the percentage reduction in planted area associated with each set aside program. Thus, the 1989 set aside program clearly had no impact on wheat planting decisions while the 1993 set aside program reduced the area planted to wheat by only about 2.5 percent. In contrast, the effects of both the 1989 and 1993 set aside programs were much larger with respect to barley. The results indicate that the 1989 set aside reduced barley acreage by 24 percent while the 1993 set aside reduced barley acreage by 43 percent (relative to no set aside policy). These findings also indicate that both the 1988 and 1992 set aside programs reduced the total area planted to wheat and barley but only because the area planted to barley declined. The net effects of the 1992 CAP reforms on wheat planting in the UK have probably been minimal. Neither the price reforms nor the 1992 set aside program reduced the area planted to wheat. All adjustments were made in relation to barley production.

These findings also raise questions about whether the CAP reforms will have their anticipated adverse impacts on EU wheat production and wheat available for export or storage in typical harvest years. If land has not been taken out of wheat production in other major wheat producing areas in the EU (for example, France) then over the next four years, the EU is likely to be confronted again with large wheat surpluses. One way to alleviate this problem would be to establish commodity specific set-aside programs instead of set aside programs for relatively broad commodity aggregates.

As was discussed above, over the period 1975-1995, the CAP may have had important indirect effects on cereals planting decisions through increasing demand for the use of domestic medium quality soft wheat in bread making (Blaxter and Robertson, Leuck). This hypothesis was examined by including the lagged ratio of the threshold price to the intervention variable for wheat, WTHINL, in both the wheat and barley models. This variable's coefficient is positive and significant at the one percent level in the wheat model and negative and significant at the one percent level in the barley model. Thus, it seems reasonable to interpret the evidence as supportive of this hypothesis. The result also highlights the importance of policy in relation to technical innovation in agriculture.

Finally, evidence on the effects of risk on farmers' planting decisions is mixed. In the wheat model, the coefficient for the risk variable RISKW, is negative, as expected, but insignificant. In the barley model, the coefficient for the risk variable, RISKB, is negative and significant. These results suggest that as the variance of barley revenues increases less land is planted to barley. Thus risk, as conventionally measured, matters in cereals land use decisions. However, as indicated by the elasticities for the risk variables (-0.002 for wheat and -0.02 for barley), even if risk does matter, its quantitative effects on land use decisions seem to be small.

Endnotes

1. Previous econometric analyses of cereals acreage decisions in the UK (Colman, 1970; Bewley, Colman and Young, 1987), the European Union (EU) as a whole (Schiff; DeGorter and Meilke), France (Oury; Liapis) and the US and Canada (for example, Garst and Miller; Morzuch, Weaver and Helmberger; Burt and Worthington; von Massow and Weersink; Miranda, Novak and Lerohl) have all relied on time series data.

2. See, for example, Chavas and Holt; Just; Pope and Just; Garst and Miller; Morzuch, Weaver and Helmberger; Burt and Worthington; Massow and Weersink; Traill; Antle.

3. Concerns about degrees of freedom have led many researchers to be parsimonious in their selection of explanatory variables in models of commodity specific land use decisions. In particular, largely because of these concerns, most previous studies of cereals land use decisions (for example, Colman, 1970; Bewley, Colman and Young; Massow and Weersink; etc.) have chosen to model wheat and barley land use decisions as functions of expected gross revenues per unit of land generated by each crop (expected prices multiplied by expected yields) rather than, as suggested by Just, allowing prices and yields to enter as separate variables. Using time series-cross section data alleviates the need for this degree of parsimony in selecting explanatory variables and thus, in this study, prices and yields are included as separate variables.

4. Wheat and barley regional yield forecasts were obtained using models based on equation (2). In each case, for each region optimal yield forecasts were obtained using an exponential quadratic function.

5. In some cases (for example, Colman and Colman, Bewley and Young) land use is assumed to depend on gross revenues per unit of land, price times yield, in the previous period or periods rather than prices and yields. It should be noted that only if prices and yields for a given crop are statistically independent is the assumption that gross revenues in the current period equal gross revenue equivalent to the assumption that expected prices and expected yields equal actual prices and actual yields in the previous period.

6. Data on land allocated to oats and oat yields were not available to the authors on a regional basis at the time of this study.

7. The models were estimated in double log form so that price and yield elasticities, rather than marginal price and yield effects on land use, are estimated to be identical among regions. The latter constrain seems to be rather implausible, given the differences among the regions in the amount of land planted to wheat and barley.

8. Yield data were not available for oats and thus it was not possible to create a relative yield variable for oats and wheat or oats and barley.

Table 1. Definition of Variables Used

NAME	DEFINITION	NAME	DEFINITION
PBW	Barley to wheat expected price ratio	PWB	Wheat to barley expected price ratio
YBW	Barley to wheat expected yield ratio	YWB	Wheat to barley expected yield ratio
POW	Oats to wheat expected price ratio	POB	Oats to barley expected price ratio
RISKW	Variance of wheat revenue per hectare	RISKB	Variance of barley revenue per hectare
WTHINL	Wheat threshold price of the previous year to wheat intervention price of the previous year ratio.		
SET89	CAP set aside 1988-92 where dummy variable equal to one for 1989-92 and zero otherwise		
SET93	1992 CAP reform set aside where dummy variable equal to one for 1993-95 and zero otherwise		

Note: Variables North through Northwest are regional dummy variables.

Table 2. Final Wheat and Barley Acreage Response Models

WHEAT ACREAGE			BARLEY ACREAGE		
Variable	Coefficient	T-statistics	Variable	Coefficient	T-statistics
INTERCEPT	4.820	-22.520	INTERCEPT	5.852	-68.200
PBW	-0.486	-2.320	PWB	-0.085	-0.480
YBW	-2.695	-3.840	YWB	-0.387	-1.640
POW	0.156	-1.460	POB	-0.148	-1.700
RISKW	-0.002	-0.300	RISKB	-0.023	-2.870
WTHINL	0.725	-3.140	WTHINL	-0.447	-2.550
North	-1.972	-19.600	North	-0.826	-39.080
York&Hum.	-0.393	-4.620	York&Hum.	-0.076	-2.820
Eastmidl.	0.157	-2.750	Eastmidl.	-0.133	-3.830
Southeast	0.377	-3.540	Southeast	0.204	-6.160
Southwest	-0.599	-8.370	Southwest	-0.104	-4.370
Westmidl.	-0.739	-11.000	Westmidl.	-0.539	-24.020
Northwest	-3.059	-14.490	Northwest	-1.626	-54.990
SET89	-0.025	-0.400	SET89	-0.431	-9.310
SET93	0.130	2.730	SET93	-0.247	-6.940
SSE[a]	153.262		SSE	160.889	
Number of Cross Sections 8	Time Series Length 21	DFE 153			

[a] SSE - Error Sum of Squares

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