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Land Use in the European Union by 2020

INTRODUCTION

Recent revolutionary changes in European agricultural policies imply dramatic shifts in future land use needs. Even a superficial examination of recent trends would suggest that large parts of current agricultural land will not be needed in the future, and the idea of a land surplus in the European Union has been repeated more insistently in recent literature (Edwards, 1986; Lee, 1987; North, 1988; *inter alia*). However, some authors argue that, with declining profitability, the removal of inputs and resources will result in a less intensive production process and significant areas of land are unlikely to leave agricultural production (Bowers, 1988; Harvey and Whitby, 1988; Harvey, 1991; Swinbank, 1992).

The importance of assessing the degree of pressure placed on agricultural land in the medium term must not be underestimated. Land is a non-renewable resource and, as a result, land use planning is long-term in nature. In addition, land use demand changes incrementally because of rigidities and inertia. There is consequently a lag between the setting and implementation of a policy and its effect. As a result, accurate predictions of land use trends have an immediate and immense value to setting good policy.

This paper presents the results of forecasts for land use change in the EU-9[1] to the year 2020. The study addresses the need of policy makers to acquire information about the future implications of current land use trends, by developing an econometric model to forecast future land use. Because of the more appropriate methodology adopted, the forecasts of land use change estimated in this study constitute a marked improvement on previously available estimates.

THE MODELLING FRAMEWORK

A dynamic simultaneous land allocation model has been developed to explore future land use scenarios in the EU by 2020. Ideally, a simultaneous model of

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the whole EU agricultural sector would have to be built in order to account fully for the relationship between prices, land use and production by endogenizing all prices. Building such a model was too demanding a task for this study and for the available data, however, and here cereal prices alone have been endogenized, with agricultural prices set to change proportionally to the change in the price of cereals after 1996.[2] Such an analysis falls short of the accuracy required for a precise investigation of future land use, but is expected to give sufficiently reliable forecasts for policy formulation.

The five land use categories considered in the model are cereal crops, oilseed crops, other arable crops (mainly fodder and root crops), permanent grassland and a residual other land uses category (mainly forest and urban uses).[3] The model has two components. In the first component, each individual land use is modelled as a function of the returns on the major agricultural products (namely cereals, oilseeds, root crops, milk and beef)[4] and income (in real per capita terms).[5] Input-deflated output prices have been used to approximate the expected returns (or profitability) in agriculture. Expectations have been modelled as an ARMA (3, 0) process, implying that price expectations depend on prices in the previous three years.

The second component is a price determination model. It is based on the premise that administered prices are not fully exogenous and cannot be set indefinitely without any reference to the current levels of domestic market imbalance and the situation in the international market(s). Ultimately, expenditure considerations would make it necessary either to reduce the market surplus or to reduce the spread between domestic and international market prices, or both. The price determination model for cereals comprises two equations, cereal price and cereal yield, and one identity. The identity defines production as the product of land and yield. Production enters the price determination equation where it contributes to setting the level of prices. The price level in turn plays a role in determining the desired yield and land use levels, in two respective equations. The land equation, of course, is also part of the first component of the model.

Crop yields have been modelled as depending on output prices deflated by the cost of inputs, on the area of land and on technological progress.[6] The price determination has been modelled as depending on the demand and production of cereals, on the price of close substitutes (notably oilseeds) and on the world price of cereals.[7]

To keep the model as simple as possible, no separate trade component has been estimated. Imports have been assumed to be constant over the forecast period. Excess supply is assumed to be subsidized and dumped on the world market. Exports are therefore assumed equal to excess supply and no stocks are assumed. World prices are assumed to be exogenous. In addition, a constraint has been introduced in the model such that domestic prices cannot fall below international prices.

All the equations have been estimated in first differences format in light of the results of unit root tests which indicate the presence of non-stationarity in the data series (not shown).[8] The equations have been estimated as log linear autoregressive distributed lag (ADL) equations.[9] The five log linear equations

TABLE 1 *Solved static long-run equation for individual land uses*

DLcerlan	=	+0.204 DLprxcer	– 0.163 DLprxrap	– 0.146 DLprxbef	+ 0.294 s0DLprxmlk	– 0.201 DLgdp85c	
(SE)		(0.080)	(0.096)	(0.042)	(0.089)	(0.082)	
Dloillan	=	–1.756 DLprxcer	+ 2.691 DLprxrap	– 1.303 DLprxrot			
(SE)		(2.502)	(4.413)	(1.501)			
DLncrlan	=	–0.733 DLprxcer	+ 0.427 DLprxrap	+ 0.247 DLprxbef	– 0.573 DLgdp85c	+ 0.164 DLprxrot	
(SE)		(0.357)	(0.246)	(0.204)	(0.314)	(0.053)	
DLpgrlan	=	–0.131 DLprxcer	+ 0.217 S0DLprxmlk	– 0.562 DLgdp85c	+ 0.014 DLprxrot	– 0.185 s1DLmlkpro	+ 0.12 DLprxbef
(SE)		(0.061)	(0.065)	(0.167)	(0.021)	(0.307)	(0.040)
DLnaglan	=	–0.051 DLprxcer	– 0.062 DLprxrap	– 0.053 s0DLprxmlk	– 0.017 DLprxrot	+ 0.175 DLgdp85c	+ 0.043 DLprxbef
(SE)		(0.011)	(0.013)	(0.011)	(0.004)	(0.018)	(0.008)
DLceryld	=	+0.029	+ 0.661 DLcerlan	+ 0.058 DLprxcer			
(SE)		(0.007)	(0.721)	(0.168)			
DLprxcer	=	+0.636	– DLprxrap	– 0.891 DLcerpro	+ 1.269 DLcerdem	– 0.102 DLprw85c	
(SE)		(0.183)		(0.249)	(0.484)	(0.053)	

Notes: DLcerlan = (change in log of) land in cereal crops, share,
DLoillan = (change in log of) land in oilseed crops, share,
DLncrlan = (change in log of) land in other arable crops, share,
DLpgrlan = (change in log of) land in permanent grassland, share,
DLnaglan = (change in log of) land in non-agricultural uses, share,
DLprxcer = (change in log of) price of cereal crops divided by price of arable inputs (index 1985 = 100),

DLprxrap = (change in log of) price of oilseed crops divided by price of arable inputs (index 1985 = 100),
DLprxrot = (change in log of) price of roots-fodder crops divided by price of arable inputs (index 1985 = 100),
DLprxmlk = (change of log of) price of milk divided by price of milk inputs (index 1985 = 100),
DLprxbef = (change in log of) price of beef crops divided by price of milk inputs (index 1985 = 100),
DLgdp85c = (change in log of) per capita real income (in ECU thousands at 1985 prices),
DLceryld = (change in log of) cereals yield (1000 kg/ha),
DLcerpro = (change in log of) cereals production (million tonnes),
DLcerdem = (change in log of) cereals demand (million tonnes),
DLprw85c = (change in log of) world price of cereals (real index 1985 = 100),
DLmlkpro = (change in log of) milk production (million litres),
s0 = dummy for: <1986 = 0; >1986 = 1,
sl = dummy for: <1986 = 1;>1986 = 0,
s0DLprxmlk = s0 * DLprxmlk,
s1DLmlkpro = sl * Dlmlkprod.

representing the land use model have been estimated individually[10] by ordinary least squares (OLS) for the period 1969–92.[11] Subsequently, the cereal land equation has been (re-) estimated simultaneously with the cereal yield and cereal price equations by FIML for the period 1961-92. All of the estimation work has been carried out using the econometric softwares PcGive 8.0 and PcFiml 8.0. For the sake of brevity, only the results of the long-run solutions of the individual equation are reported in Table 1.

For the five land use equations, all of the direct price elasticities in Table 1 have the expected positive sign. Note that cross-price elasticities in such a system do not have a definite expected sign. Complementarity among crops may arise from particular rotation features or from particular patterns of use of the different fixed factors (Sadoulet and De Janvry, 1995). In addition, complementarity may arise between crops and livestock production, since the former can be used as inputs in the production of the latter. The results displayed in Table 1 are therefore in line with economic theory.[12]

THE FORECAST SCENARIOS

The model is used to produce forecasts of land use in the EU by 2020. The forecast scenario accounts for the introduction of the MacSharry reforms, the GATT Uruguay Round agreement and the Berlin reforms of 1999 (MGB scenario). In brief, the MacSharry and the Berlin reforms introduced a reduction in the level of price support and a compulsory set-aside of arable land. Farmers were compensated both for the price reduction and for the area set-aside. The GATT agreement introduced a reduction in aggregate agricultural support (which in the case of the EU is mostly satisfied by the reductions carried out under MacSharry) and, more importantly, a reduction in the level of subsidized exports. Under the MGB scenario, the model has been modified to introduce the MacSharry and Berlin price reductions, the set-aside constraint and the relevant compensations. The agreed GATT limit on subsidized exports has also been incorporated into the model.

In order to produce the forecasts it is necessary to make assumptions about the future path of the exogenous variables. These are the world price of cereals, the demand for cereals and income per capita. (As discussed above, cereals imports and milk production have been assumed to stay constant after 1996). The world price of cereals has been projected to follow a logarithmic trend from 1997 onwards. This appears to fit well with the historical data, and gives plausible projections to 2020 (approximately a 60 per cent reduction in real terms over the 25-year period). The demand for cereals in the EU has been virtually stable up to 1992, before increasing substantially in the last few years because of the high world market prices for cereal substitutes. The price competitiveness of cereals vis-à-vis oilseeds, however, can be expected to remain relatively stable in the future since the two regimes have been unified under the Berlin reform. The domestic demand for cereals has therefore been assumed to remain constant over the forecast period. Finally, income per capita has been projected to follow a linear trend after 1996. This gives plausible projections to 2020 (about 1.7 per cent per annum).

The sensitivity of the results to the assumptions about the level of world prices, cereals demand and income per capita needs to be thoroughly investigated. Alternative scenarios for these variables have therefore been explored. The alternative scenario for world prices is based on the IFPRI world price forecasts generated by the IMPACT model (approximately a 15 per cent reduction in real terms by 2020 – see Rosengrant et al., 1995). The alternative scenario for cereal demand assumes an increase of 1 per cent per annum after 1996, to account for the increase in the use of cereals as livestock feed.[13] Finally, the scenario for income per capita displays a faster increase in the level of income (about 3 per cent per capita per annum).

The results of the forecasts under the MacSharry–GATT–Berlin (MGB) scenario are presented in Table 2. Baseline results (that is, without the MGB policy changes) are also presented in Table 2 and Figure 1. The agricultural area in EU-9 by 2020 is expected to decrease by 18 per cent (this is about 16 million hectares, an area equivalent to slightly less than three-quarters of the UK, or larger than Ireland, Denmark, the Netherlands and Luxembourg together). Most of this reduction in agricultural land occurs from permanent grassland (about 8 million ha.) and the area devoted to fodder and root crops (about 4 million ha.). Oilseeds land also appears to decrease significantly. Cereal land remains about constant. It is worth noting that these changes in land use occur in spite of an increase of almost 100 per cent in cereals production by 2020 (cereal yields are forecast to nearly double over the period).[14]

The introduction of the MacSharry reform accelerates the exit of land from agriculture by almost 15 per cent compared to the baseline scenario. The GATT agreement has no effect on the transfer of agricultural land, since it does not itself change the set of incentives affecting land use. However, the GATT limitation on the use of export subsidies effectively imposes a constraint on production which translates into a rate of set-aside of arable land above 50 per cent by 2020. The Berlin reform lowers domestic cereal prices to the level of the international prices (by 2005) and, therefore, makes set-aside redundant. The Berlin reduction in prices, however, further accelerates the exit of land from agriculture.

Overall, the reforms of the 1990s have substantially increased (by about 30 per cent) the area of land surplus to agriculture by 2020. In fact, most of the acceleration in the transfer of land is concentrated in the years immediately following the reforms, with the series going back to their normal trends by about 2005–10. Given this initial set of results, it is important to determine the sensitivity of the forecasts with respect to the assumptions made about world prices, cereal demand and income per capita. Three modified MGB scenarios have been run, varying one of the assumptions on each occasion. The results are presented in Table 2 as MGB-World price, MGB-Demand and MGB-Income scenarios.

The change in the assumption about cereals demand has very little impact on the results of the forecasts. This is probably because its impact on raising

TABLE 2 *Projections for agricultural land in EU-9 to 2020 and policy simulations (million hectares)*

		Agricultural land[1]	of which: Set-aside	Cereal land	Oilseeds land	Root and fodder land	Permanent grassland	Non-agricultural land
1960	EUROSTAT	98.830		26.213	0.311	23.882	41.760	51.403
1990	EUROSTAT	89.259		23.939	4.125	17.188	38.078	60.065
Basic scenarios								
2020	Baseline	77.778	0.0	20.916	3.231	16.678	30.463	72.706
2020	MacSharry	76.446	6.2	22.216	2.719	15.943	30.068	74.049
2020	GATT	76.446	18.8	22.216	2.719	15.943	30.068	74.049
2020	Berlin (MGB scenario)	73.461	0.0	23.555	1.076	13.322	30.008	77.034
Sensitivity analysis								
2020	Berlin (MGB-Demand)	74.156	16.2	24.752	1.215	12.588	30.101	76.339
2020	Berlin (MGB-Income)	69.653	0.0	23.711	1.099	12.045	27.298	80.841
2020	Berlin (MGB-World price)	74.590	0.0	24.988	1.407	12.488	30.207	75.904

Note: 1. The forecasts include 5.5 million hectares to account for permanent crops and some residual agricultural land.

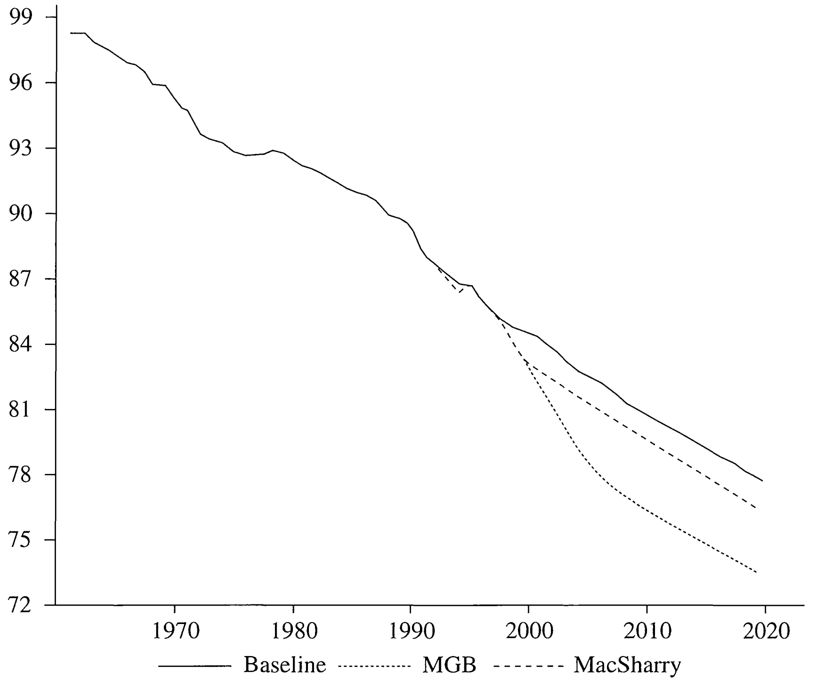

FIGURE 1 *Agricultural land in EU-9, 1961–2020: baseline, MacSharry–GATT and MGB scenarios (million hectares)*

the price level is not expected to be too large, as prices are more significantly affected by the impact of the reforms. Similarly, assuming a moderate rate of decrease in world prices also appears to have very little effect on the results. The assumption about income, on the other hand, has a strong impact on the land use forecasts. Assuming a faster increase in income per capita substantially raises the area of land moving out of agriculture and into other uses. This is because a higher level of income corresponds to a higher demand for non-agricultural land uses.

In any case, even under these alternative scenarios, the forecasts indicate that a sizeable area of land will leave agricultural use. Most of this land is coming out of permanent grassland, and is, therefore, marginal land which is leaving agriculture because of the reduction in its profitability. It seems plausible that a very substantial part of this land will actually be abandoned.

A number of limitations in the model have been indicated. Notably, the assumptions about relative prices in agriculture, and about the exogeneity of cereals demand and the level of the world prices, represent a source of weakness of the forecasts. In addition, there are a number of instances in which it would be desirable to distinguish between the short- and long-run relationships between the variables. For instance, in the yield equation, one would expect to find a relationship binding the yield level to the area of land, such that, in the long run, the level of yield is positively related to the area of land by an equilibrium relationship, while in the short run the two behave as substitutes. Cointegrating vectors, however, have not been estimated owing to the small sample size, and remain as a desirable extension for future studies.

CONCLUSIONS

The forecasts of land use in the European Union by 2020 presented in this study indicate that a very significant amount of land will leave agriculture in the next 20 years. Assumptions about the level of world prices and income per capita influence the forecasts; nevertheless, it appears that no fewer than 14 million hectares will leave agriculture by 2020 (15 per cent of EU-9 agricultural land in 1990).

The results of the forecasts indicate that the profitability of agriculture vis-à-vis alternative land uses plays an important role in determining the amount of land leaving agriculture, while it has little effect in influencing the level of yields. In fact, the decrease in the intensity of production resulting from price reductions is not very large compared with the effect of technological improvements on yield. Even reforms of the order of those carried out during the 1990s only slow down the rate of growth in yields temporarily. As real prices in agriculture continue to fall, therefore, there will be no significant extensification of agriculture. The intensity of agricultural production may be reduced a little, but this will not be sufficient to prevent very large areas of land from leaving agriculture.

An acceleration in the exit of land from agriculture is currently occurring as a result of the agricultural policy reforms of the 1990s. A large part of this 'surplus' land is set to be left abandoned. Clearly, adequate policies need to be implemented to prevent serious environmental effects. The value of continuing to limit urban expansion or, on the other hand, the encouragement of high-quality low-intensity organic agricultural production, or the creation of more recreational and/or environmentally protected areas, needs to be carefully (re)assessed.

NOTES

[1]Owing to the importance of using time series of a sufficient length, the study is limited to the nine countries which already belonged to the European Union before 1982, therefore excluding Greece, Portugal, Spain, Austria, Finland and Sweden.

[2]Specifically, it has been assumed that, within agriculture, relative prices will continue to change in line with historical patterns since the institution of the CAP.

[3]In line with historical experience, permanent crops have been assumed to remain constant over the forecast period.

[4]The prices of milk and beef have been included in the analysis as proxies for the profitability of livestock products, whose production has an impact on land use. The relationship between the milk and beef prices and the demand for fodder land and grassland is by no means a direct one, and ought to be better specified. This simple, specification has been adopted here because a

careful model of livestock production, and its land use requirements, is beyond the resources available for this study. The difficulty in dealing with the livestock sector within the model is further complicated by the introduction of the milk quotas regime in 1984, which profoundly changed the nature of the market for milk. With the introduction of quotas in 1984, milk production is no longer dependent on the price of milk but it is determined by input prices and the level of quota, such that overshooting the quota is negatively related to production in the following years because of the heavy fines. To account for the effects of the milk quotas, the impact of milk price in the land use equations is limited to the period before 1986 (the year when the reform effectively became enforced) and milk production is introduced as an explanatory variable in the permanent grassland equation from 1986 onwards. Milk production is assumed to remain constant over the forecast period.

[5]Income is introduced in the equations to act as a proxy for the (increasing) value of both forest and other non-agricultural land uses.

[6]Owing to the absence of real data about weather, the weather effect has been simply omitted, on the assumption that its effects are randomly distributed.

[7]Demand for cereals has been assumed to be exogenous. This is because the demand for cereals is heavily determined by its feed use (approximately 65 per cent) and hence by developments in the livestock sector (see note 4 above).

[8]It should be obvious that all land (share) series must be stationary in the very long run by definition. However, although the series are stationary in the very long run, it is not reasonable to conduct inference on the series in levels. For inference to be valid, the data used in the analysis have to be stationary.

[9]For the five land use equations, the choice of the log linear functional form ensures that the estimated land shares are non-negative, but it does not ensure additivity. Additivity has therefore been imposed via an ad hoc restriction. In addition, the set of double log land demand equations cannot be derived as the result of profit maximization. This functional form, however, represents a first order approximation to any more complex functional form (by Taylor's expansion) and a set of log linear equations can therefore be taken as a good approximation to the true system of demand equations derived from profit maximization. Note that this format also imposes the restriction that elasticities are constant.

[10]Joint estimation was not feasible because of the limited number of degrees of freedom.

[11]The period 1993–6 has been used to test the forecasting performance of the model (not shown).

[12]Tests for homogeneity of the land use equations have been carried out (not shown). The null hypothesis of homogeneity is not rejected in any of the land equations at the 1 per cent level and is rejected only in the permanent grassland equation at the 5 per cent level. The results of these tests therefore appear to be consistent with profit maximization behaviour. A formal test for the symmetry of cross-price effects in the system of equations is not feasible because simultaneous estimation of the land use equations has not been carried out (because of the lack of degrees of freedom) and hence it is impossible to impose/test for cross-equation restrictions.

[13]This may seem small in comparison to recent increases since 1992, but is extremely large in relation to past experience. Recent changes are seen as a one-off adjustment to the reforms.

[14]A doubling of cereal yields by 2020 may appear striking. However, such high levels of yield are already achieved in laboratory trials and are close to yields achieved in the most productive areas of the Community.

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